POWER PLANT ENGINEERING

Trade-mark reg. U. S. Pat. Office

VOL. XXIV CHICAGO, FEBRUARY 1, 1920 No. 3

Power House Foundations

TESTING SOILS; METHODS OF COMPACTING; COLUMN FOOTING; DRAINING; CONSTRUCTION KINKS. BY E. M. LURIE

OPERATING REQUIREMENTS will largely determine the location of the new power house within certain prescribed limits. If, within these limits, choice of several sites is available, the economies of construction will then be considered. On ground which is practically level with a variation of elevation not exceeding say 8 to 10 ft. in the limits of a building 150 ft. long, an examination should be made for quality of bearing soil and distance from railroad or motor truck facilities for transporting construction materials.

For rolling ground when the variation in elevation within the limits of the proposed foundation may exceed 10 ft., the question of the cost of excavation also enters the discussion. Levels should be run on the tentative sites to determine the amount of excavation required. However, the cost of removing the soil is based not only on the quantity but likewise on the kind. This is determined by digging test pits on the sites and noting the character and depth of the various strata. As rock excavation is the most expensive, being from 3 to 10 times more so than soft clay, when any considerable amount is encountered, the importance of carefully determining the exact nature and quantity of it should not be overlooked. Loose rock and boulders are generally removed by steam shovel, but solid rock requires blasting in addition, a relatively tedious and expensive process. Again, if a

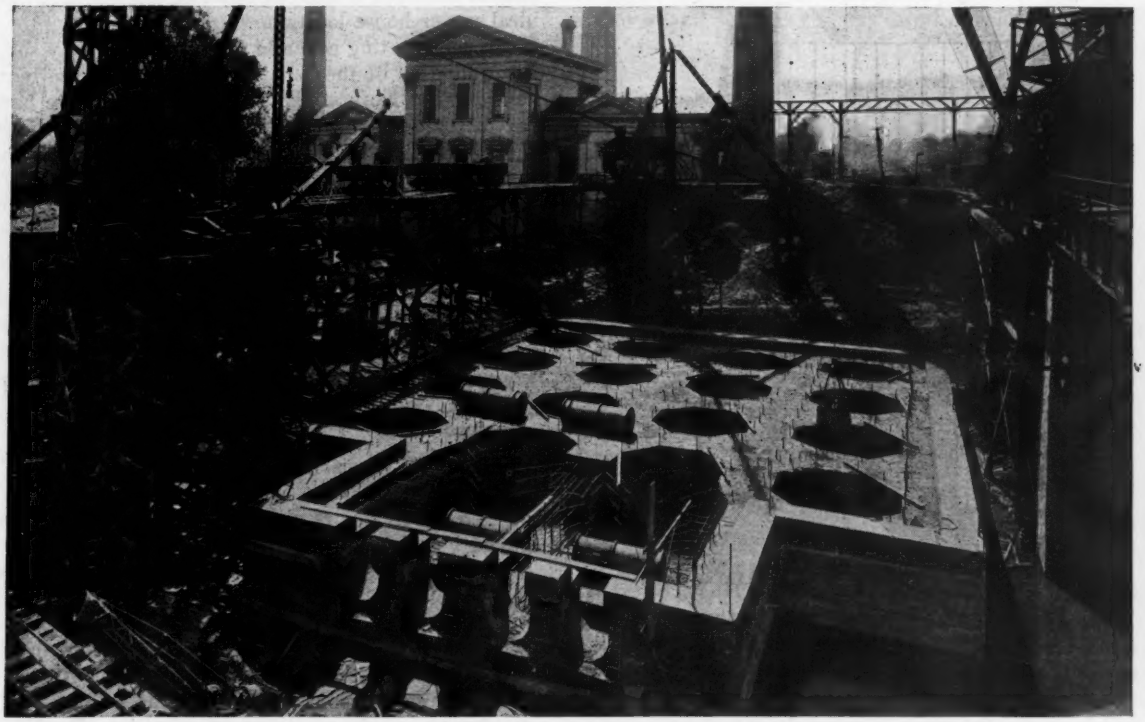


FIG. 1. FOUNDATION OF LOUISVILLE WATER CO. PUMPING STATION PUT IN BY THE OPEN DREDGING WELL CAISSON METHOD—PHOTO FURNISHED BY PORTLAND CEMENT ASS'N

good bearing medium is found near the surface, excavation will necessarily be cheaper than if it exists at a considerable depth. Means for determining the bearing power are discussed in later paragraphs.

Having determined the relative cost of excavation, we are prepared to consider the relative cost of constructing the foundations proper. The greater the bearing power of the soil, the less spread of concrete will be required for the footings and foundations.

Baker's "Masonry Construction" gives the following permissible safe loads:

	Bearing power in tons per sq. ft.	
	Minimum	Maximum
Solid rock in native bed.....	200	—
Rock equal to best ashlar masonry	25	30
Rock equal to brick masonry.....	15	20
Rock, poor.....	5	10
Cemented gravel	8	10
Sand, dry, compact, well cemented.	4	6
Sand, clean, dry	2	4
Clay, in thick beds always dry.....	6	8
Clay, in thick beds moderately dry.	4	6
Clay, soft	1	2
Quicksand, alluvial soils, etc.....	0.5	1.0

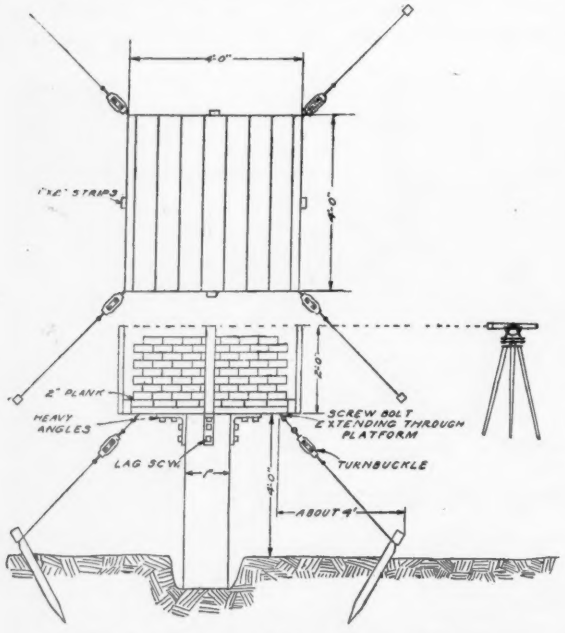


FIG. 2. METHOD OF TESTING BEARING SOIL

Footings in solid rock for the building proper are usually constructed of plain concrete only. Where fissures in the rock indicate instability, ¾-in. reinforcing rods are embedded longitudinally in the concrete at such points. This, however, is unusual.

Engine foundations which require absolute rigidity are also, as a rule, built of plain concrete only, when on solid rock, each foundation being made deep enough and being poured continually so that it acts as a monolith. When headroom or other conditions limit the depth of the machinery foundation, it is frequently reinforced in both directions so that the steel forms a mat embedded in the concrete.

Although concrete materials—cement, sand, gravel or crushed stone, are within comparatively easy reach the country over, and the cost of plain concrete does not vary materially, the cost of reinforcing steel ranges considerably as between different parts of the country, so that a decision as to whether to use plain or reinforced concrete rests largely on the relative costs of steel and concrete in the locality in question.

Unquestionably, it is more conducive to economy and rapidity of construction, if plain concrete only is employed. The proper placing of steel is of material importance for effective use and this requires more supervision and a better grade of labor. Deliveries of reinforcing steel are somewhat uncertain in some parts of the country, so that the work may be held up. This, necessarily, is an important point. Therefore, it has become recognized as good practice to increase the depth of foundation, using more concrete than ordinary requirements would necessitate, to give the same relative rigidity, as would be obtained with a lesser quantity of concrete in combination with reinforcing steel.

The preceding with reference to concrete foundations on rock also holds true on gravel footings in which the particles are knit together by cementitious materials.

Sand which is confined naturally or otherwise makes an excellent foundation. By constructing sheet piling or concrete retaining walls to prevent the sand from being pushed sidewise, a sandy site can be transformed into an ideal power house location.

In constructing concrete foundations on clay soil, the determination of the type of foundation to use requires considerably more study than that for any we have so far discussed. The bearing power of clay, as given in the tables, varies in so great degree that although for buildings which do not impose a heavy load on the foundations an arbitrary assumption can be made based on an examination of the soil, the only safe and economical course to pursue for footings under heavy machinery is to dig test pits and conduct load tests to determine what pressure the soil really will bear.

Testing Bearing Power of Soils

A simple arrangement which will enable a load test to be conducted expeditiously at small cost is shown in Fig. 2.

The outfit consists of a 12 by 12 timber post (an 8 by 8 post built out at the bottom to 12 by 12 will do) supporting a 4 ft. square platform made of 2-in. planks and guyed by wire stays as shown in the illustration. The pit is dug down to the stratum of soil which is expected to be used as the bearing medium, leveled off, and the test platform placed and guyed to a vertical position by means of wires and turnbuckles. The wires should be attached to substantial stakes driven in the ground or to other stationary objects. Convenient loading mediums are bricks, pig iron, or cement in sacks. Readings are taken on sighting strips attached to the platform, by sighting on them through a leveling instrument. A homemade level which can readily be built up around a carpenter's level is shown in Fig. 3. Readings should be taken on all four strips to take care of the tilting of the platform due to unequal settlement, not taken care of by the turnbuckle on the guy wires. The average of all four readings will show the elevation at any time.

Tension in the wires should be only such as will suffice to keep the platform level.

After the initial compacting of the soil which is indicated by a comparatively rapid lowering of the platform under initial load the platform will come to rest. This can be considered as the zero point. The platform should then be loaded to say half of the expected ultimate bearing power and left for a day. If no settlement is shown by the level, the load should be increased to three-fourths of the expected load and left for another day. The load can then be increased to seven-eighths and in another day to full load and so on. When the load approaches the critical point settlement should be carefully watched for.

Uniform loading of the platform is a requisite to a satisfactory bearing power test and irregularities should be promptly remedied.

When the actual settlement exceeds ⅛ or ¼ in. in 24 hr. (by taking the average of all the sight rods on the platform) the load should be allowed to remain another 24 hr. If the settlement increases the actual superimposed load plus the weight of platform is considered as the ultimate bearing power of the soil. The safe bearing load should be taken as half this for walls and columns supporting stationary loads and from a third to a fifth of the ultimate load for foundations supporting engines and movable loads.

Computing Column Footings

The size of column footings can readily be computed knowing the safe bearing load of the sub soil and the load coming thereon. Suppose we are supporting one of the four corners of a 30-ton coal storage bin. Adding the dead weight of the bin we have a total load of say 36 tons which means that each column footing must support 9 tons. From the bearing test we have found the ultimate bearing power to be 3 tons and the safe load 1½ tons per sq. ft. Area of footing required is $9 \div 1\frac{1}{2} = 6$ sq. ft. As footing dimensions are usually to the nearest 3 or 6 in. and footings are made square unless interfering with some other part of the structure, this one would be 2 ft. 6 in. square on the bottom. This would be stepped up, each course being 9 to 12 in. thick and the horizontal effect between courses not exceeding two-thirds of the rise. In other words, for a 12-in. step the offset would be 8 in. on each side or a total of 1 ft. 4 in. on both, making the second course 2 ft. 6 in. — 1 ft. 4 in. = 1 ft. 2 in. square which probably would have to be increased a few inches to accommodate the column base plate.

Wall footings are designed similarly. In computing the weight resting on the footing per foot of wall length it is necessary to take the weight of the wall material from footing to roof, the portion of each floor load carried by the walls including the portion of the dead load of all machinery supported and not carried by columns and one-half the live load, assuming that the live load will not occur simultaneously over the whole structure. Roof load including maximum snow and dust load added to dead load or wind load which depends on the slope of the roof, also must be proportioned among the various supporting mediums and ultimately carried down to the footings.

On soft clay, spread footings are extensively used and sometimes the bearing power is so small that a reinforced concrete mat is laid under the entire area occupied by the building, and this is not an uncommon procedure in the case of all engine foundations, the walls footing being separate.

Piling

For foundations on boggy or made land, piling or caissons carried down to a substantial bearing will generally be found necessary. Wooden piles are commonly used although concrete piles of various types are meeting with considerable success and for extensive operations where a large number of piles is required they merit investigation.

Piles are of two kinds—column or friction, depending on whether a bearing on a hard sub-stratum is obtained, or whether the skin-friction of the pile furnishes the support. Piles of the first kind are frequently used on submerged lands where under the alluvial deposits a good bearing medium is encountered. Column piles, so called because they act as such in the structure are considered as unsupported length from the top down to

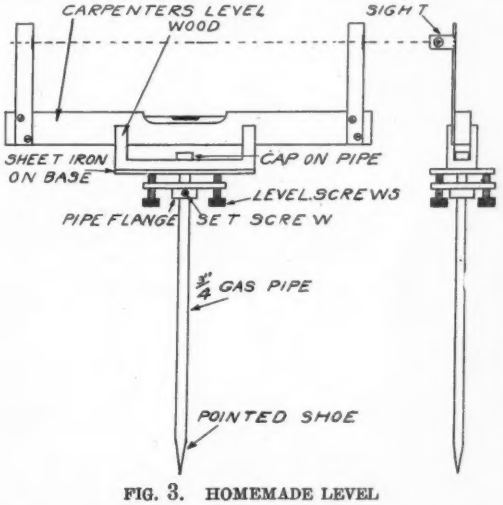


FIG. 3. HOMEMADE LEVEL

the point where lateral deflection is prevented by the sub-soil. The bearing power of a column fixed at one end is given by the formula:

$$P = \frac{9 \times (3.1416)^2 \times E \times I}{4 L^2}$$

Where

P = ultimate load

E = coefficient of elasticity of column (pile) material

L = unsupported length.

I = rectangular moment of inertia.

If the pile is of wood and has a diameter 12 in. or less and the unsupported length is more than 25 ft., the ultimate load as given by the above formula may be less than that often placed on the pile—a dangerous state of affairs. The limit of the loading power is reached in any case, when the safe crushing strength of the wood, longitudinally, is approximated. This varies from 900 to 1250 lb. per sq. in. so that a handy rule to use, for wood pile, is

W = 900 to 1250 × square of diameter of pile where W = safe load.

The safe bearing power of concrete pile used as columns will depend on this diameter and the amount of reinforcement and no ready rule can be given here.

For piles depending for their bearing power on their skin friction, an actual field test in which the amount of settlement produced by pile driver head of known weight falling a certain distance is used in various formulas will give the bearing power of the pile. Considerable difference of opinion exists as to the merits of these various formulas.

Piles not sunk by means of pile drivers are tested by loading them with a platform attached in like manner to that described for the soil bearing power test.

Sometimes, instead of driving piles to improve the bearing power of semi-liquid soils, the same result is obtained by draining the site, by adding a layer of sand or gravel, or by compacting the soil.

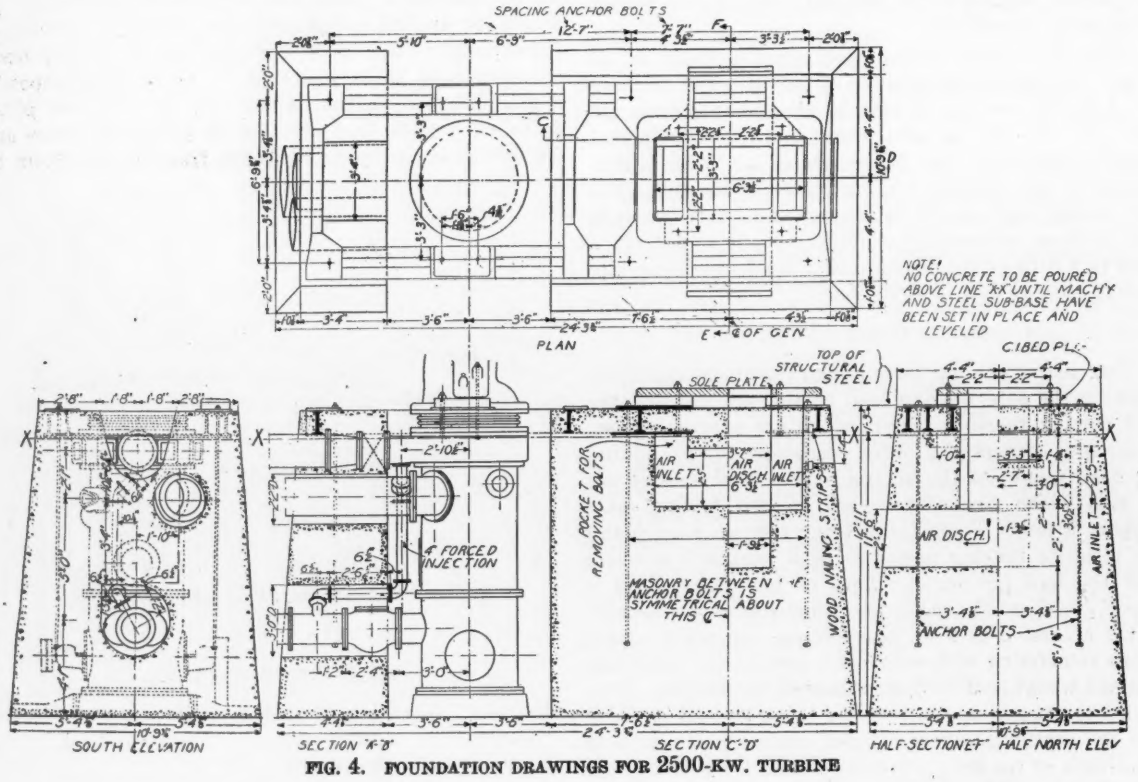


FIG. 4. FOUNDATION DRAWINGS FOR 2500-KW. TURBINE

Draining the Soil

Clay and sandy soils frequently are so situated that they are subject to saturation by the overflowing of neighborhood streams or by the presence of nearby springs. In a saturated condition these materials have relatively small bearing power; drained, they become compact and solidified and without further process are enabled to bear loads much larger than originally possible.

Water will find its way to the footing, by running down the side of the wall, by seepage from surrounding soil, through a seam of sand or from an underground spring.

Concrete or clay drain tile, the former is recommended as being the more permanent, laid dry just below the level of the footing on a bed of sand, surrounded top and bottom with layers 6 to 12 in. deep of crushed stone, gravel, or broken bricks in order to facilitate drainange and drained to the nearest sewer or other outlet, will suffice to take care of the drainage problem in most instances. In others, it may be necessary to build a sheet piling cofferdam with clay puddle between or even, perhaps, construct a permanent concrete retaining wall around the foundation proper, to protect it from inundation from the high water of adjacent areas. If good bearing only is desired, the use of piling instead of drainage tile should be considered in such foundations.

However, dry boiler and engine rooms are conducive to cleanliness and orderliness and promote the good health of the employes. The drain tile, therefore, will not only increase the bearing power of the foundations, but will do much to eliminate automatically the insanitary conditions prevalent in damp buildings, the use of a pump for this purpose being dispensed with.

Another method used for improving the bearing power of wet soils is to place layers of crushed stone or gravel on the wet subsoil. The lower layers combine with the wet soils to form a stiff puddle over which the subsequent layers of stone distribute the pressures equitably. The depth of gravel required depends on the nature of the soil, the load and various other conditions so that nothing short of actual experience with such conditions will give the engineer the requisite knowledge of the subject.

Increasing the Bearing Power

To increase the bearing power of the soil by com-

pacting it, moist sand in layers is placed over an area a little larger than the foundation. Each layer is carefully tamped and compacted. Experience has shown this to be a method which meets with considerable success.

Two other methods of compacting soils have been made use of. They are firstly, by driving wood piles, extracting them and filling the depressions left with sand; secondly, by making use of a compressor weight which is dropped from the leads of a pile driver or from some other elevated point onto compressible soil; the resulting depression hole is then filled with concrete. This is a system of building up concrete piles which is used extensively by foundation contractors. The use of sand in conjunction with wood piles as previously described, is not general, and no doubt, spread footings or some of the other methods already described are easier of application and likewise cheaper.

house at a mine in Rock Springs, Wyoming, see Fig. 4. An 18-in. continuous concrete slab was used under all the turbine foundations shown.

The lack of depth also introduced other complications. A special condenser of the low level jet type had to be built and the deep concrete arch in the turbine foundation over the condenser, usual in foundations of this kind, was omitted and a heavy structural steel sub-base of lesser depth used in its place. In erection, the turbine was bolted to the steel sub-base and the latter was then leveled, bolted in place and grouted to the concrete foundation. The steel sub-base, made of 12-in. I's of 55 lb. each, not only reduced vibration to a minimum, but also acted as a tie for the two sections of the concrete foundation.

Openings for the piping were carefully laid out so that the piping could be assembled handily to obviate

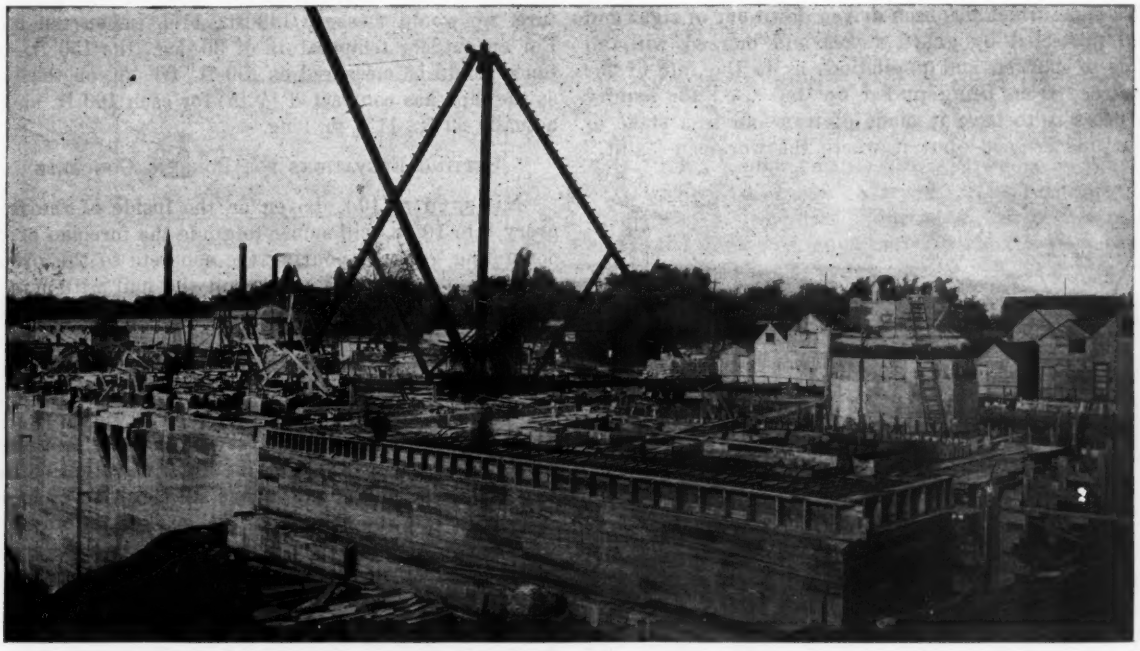


FIG. 5. SOLID REINFORCED CONCRETE FOUNDATION FOR THE FAIRVIEW SEWAGE PUMPING STATION IN DETROIT—PHOTO FURNISHED BY PORTLAND CEMENT ASS'N

Sometimes in excavating for foundations a peculiar condition of the subsoil is encountered as the depth is increased. Instead of being firmer and more compact, as would reasonably be expected from the effect of the pressure of the upper strata on the lower, the soil is more moist and pockets of quick sand which may underlie a part or the whole of the area to a considerable depth may be uncovered.

If the upper stratum is continuous and the bearing power is sufficiently great as determined by a test such as has been described to take care of the load a reinforced concrete slab 1 to 2 ft. thick over the whole area will generally be found cheaper than piling or caissons even when the latter are feasible, excepting for extremely heavy loads.

Foundations for a Mine Power Plant

Such a condition was found in excavating for the foundation of a new 2500-kw. turbine in an old power

subsequent cutting and patching and without materially weakening the foundation. Although this would seem to be a trifling matter it appears to be overlooked by many plant engineers who send out drawings with only the general turbine dimensions spotted in, assuming apparently that the piping can be taken care of later. Cutting concrete is a tedious and expensive proposition.

Starting the Foundations

Having decided what the nature of the foundation is to be, construction operations are started by excavating down to the bearing stratum. In every case the excavation for a permanent structure must be carried down at least to the frost line which varies from 3 to 6 ft. below ground line, in different parts of the country. Even foundations on rock when above frost line are not immune to frost as water may get under the foundation through cracks or holes and freeze with resulting damage.

No attempt will be made here to describe layouts as to mixing plant arrangements or to tell the number of men needed for any particular concreting operation. In the writer's experience as field engineer on plant construction, however, he has encountered various short cuts in the engineering features connected with the laying out of the work which have proved helpful and believes they will be of assistance to others.

Bench Marks and Sighting Points

One of the things most difficult of attainment on a construction job when the work is done on an undeveloped site is the maintenance of permanent bench marks which will not be run over by teams, pulled up by the workmen or buried under construction materials. Apparently no amount of cautioning the labor foreman, the teamsters, or anybody else, will be permanently effective. The only thing that will prevent a bench mark stake which has been driven down out of sight and been protected by guard stakes and marked with all kinds of caution and predictions as to the fate of the disturber from being pulled up and used for sundry purposes is to have it made of iron—an iron stake or iron pipe is good—put it where the workmen "aint,"

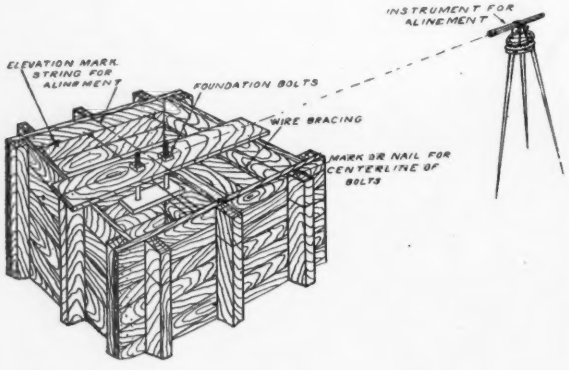


FIG. 6. METHOD OF SETTING TEMPLATE BOARD AND ANCHOR BOLTS

drive it down flush with the surface, dig a pit around it 24 in. in diameter and 2 ft. deep and fill it with concrete to within an inch of the top of the bench, guard it with sloping guard stakes and trust in God.

For the purpose of maintaining points so that the building lines are easily found, batter boards substantially built and braced should be placed at least 10 ft. outside of the building lines. Boards placed closer than this are almost sure to be knocked down or pulled out in the course of excavation and construction. The horizontal board should be at least a 1 by 6-in. with the 6-in. dimension vertical, and should be made long enough at the beginning to take care of outside and inside excavation lines, the building lines and offsets not exceeding 4 ft.

Even well built batter boards, however, are likely to be disturbed, so iron pipes or stakes driven flush with the ground and concreted as described for bench marks should be placed on all important building lines far enough from the building to be reasonably immune to destruction. This work involves a little expense at the start, but will be found to be worth its cost many times over by saving time lost in trying to retrace destroyed marks and points, in making the mason and carpenter foremen independent of the continual service of the instrumentman and in reducing the chances for serious and costly errors in location.

Correcting Measurements for Temperature

Just a caution here as to the necessity for allowing for temperature variations in measurements. Although no serious error is introduced in neglecting to make a temperature allowance on buildings less than 75 or 100 ft. long, on those of greater length a lot of "fudging" in the location of anchor bolts can be avoided by taking care of the matter at the start. A good rule to follow is to allow a quarter inch (or .02 ft. on tapes graduated in feet and hundredths) for each hundred feet for every 30 deg. difference above or below 62 deg. For example, in making a measurement of 150 ft. at 90 deg. temperature, we would measure 149 ft., 11⅝ in. on the tape. For an outdoor temperature of 30 deg., the 150 ft. distance would be measured as 150 ft., 0⅜ in. on the tape as the tape has contracted ¼ in. for each 100 ft. and is actually 99 ft., 11¾ in. long.

Setting Elevations for Pouring Concrete

Nails, 8d to 10d, driven on the inside of the form every 8 to 10 ft., will suffice to guide the foreman of the concreting gang in pouring the concrete to the proper elevation. A ring drawn around the nail with lumber crayon of distinctive color will help to catch his eye. Sometimes, on particular work, the carpenter foreman will pull the nail out and nail a 1 by 2 wood strip on the inside of the form from nail mark to nail mark giving the concrete men a continuous guide to work by.

If the nails or other marks either for elevation or for line cannot be placed at the exact elevation or line, they should be placed 2 ft. above the elevation or to one side of the line and so marked. A mark offset only 1 ft. has frequently, on account of its proximity to the proper place, been assumed to be the final point and used accordingly.

In setting anchor bolts for a column, they should be hung through holes in a templet board properly spaced. Both center lines for the bolts should be marked on the board, which should be long enough to extend across the form. By using a transit in one direction and a chalk line drawn across center line marks on the form in the other direction, as shown in Fig. 6, the bolts can readily be located. Sometimes chalk lines are used in both directions or two instruments can be used. As more than one transit is not likely to be available at any time the first method mentioned—chalk line in one direction, instrument in the other—will, in general, be the one found most adaptable for ordinary uses.

With the anchor bolts right for line, they must be set to elevation. This can be done, when they are suspended from the templet, by merely adjusting the nuts. Suppose, in Fig. 6, we are to set the anchor bolts for columns supporting the elevating and conveying machinery. The bottom of the milled plate on the column is to be set at elevation 100 ft.-0 in.; the anchor bolts are 1 in. in diameter and the column base consists of the ¾-in. plate and ⅜-in. angles resting on it. Then the top of the angle surface on which the nut bears would have an elevation

of 100 ft.-0 in. plus ¾ in. plus ⅜ in., or 100 ft.-1⅛ in. The nut would be 1 in. thick, and with the thread projecting ½ in. above the latter, would be at an elevation of 100 ft.-1⅛ in. plus 1½ in. = 100 ft.-2⅝ in., which would be the elevation required and the nut would be screwed on or off until this elevation is reached.

To set the nails for the top of the concrete of this column pier, the procedure would be as follows:

The milled plate on the column rests on a ⅜-in. steel bed plate on top of the concrete. It is embedded in concrete grout after the concrete has set. Not less

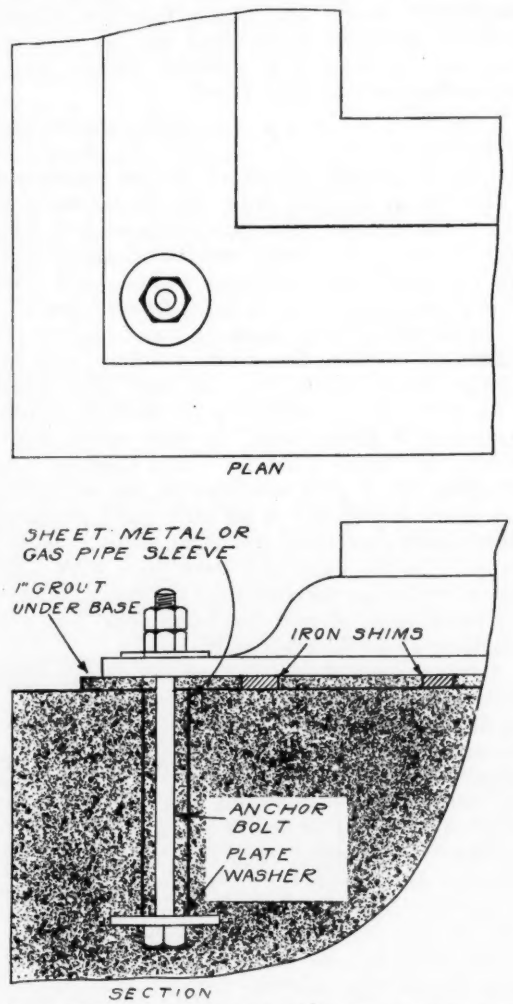


FIG. 7. SHEET METAL OR PIPE SLEEVE FOR ANCHOR BOLT ADJUSTMENT

than ½ in. should be allowed for the grouting and frequently as much as 1-in. clearance is provided for this purpose. Assuming a ⅜-in. bed plate and an additional ½-in. under it for grouting we have as the elevation of the poured concrete 100 ft. 0 in. — ⅜ in. — ½-in. = 99 ft.-0⅛ in., and the nails will be set accordingly.

Anchor bolts for machinery foundations are set in a manner similar to that described for column bolts. The thickness of the machinery base and the diameter of the bolt or thickness of nut will in this case determine the height of the upper end of the bolt.

As a rule, no masonry plate is used under the bed plate of the turbine or engine, but a good inch should be left for grouting. The machine is set on iron shims on the concrete base which are adjusted until it has been properly leveled and then grouted in place, the shims being left in place.

Sheet metal or gas pipe sleeves 3 to 4 in. in diameter, depending on the diameter and length of bolt around the anchor bolts for their entire length are commonly used for machinery foundations and, in fact, for all anchor bolts which may need lateral adjustment. They will be found exceedingly useful in practice, as they greatly expedite the final erection of the machinery. Sheet metal—24 gage—will do the work as well as gas pipe and usually for less money. When the machine has been lined up on the bolts, the annular space between the bolt and sleeve should be filled with a good cement grout made of 1 part of cement to 1 part of sand.

Reversed Series Field on Generator

By Jas. T. Kane

WHEN replaced in service after being overhauled, a 500-kw. motor-generator set consisting of a 2300-v. two-phase induction motor and a 600-v. compound generator, apparently operated satisfactorily. Some time elapsed before it carried full load. Its load consisted of some 600-v. motors driving the old machines in the factory, which were used only when it could not be avoided.

With a light load, the generator easily maintained its voltage; as this load was increased, a strengthening of the shunt field was necessary; and at full load, normal voltage could not be obtained. The speed of the induction motor tested normal. Over-compounding the generator brought no success. Finally we tried reversing the series field, and that was the solution.

In reconnecting the generator a mechanic somehow had got the series field leads twisted. This was not apparent when the set was tested, nor while it carried a light load; but when the load was well increased, the series field became sufficiently excited to exert enough demagnetizing effect on the shunt field to lower the terminal voltage.

Seventh annual report of Children's Bureau states that many American-born children are growing up illiterate. Of 19,696 children between 14 and 16 yr. old, to whom certificates were issued under Child Labor Act of 1916, more than ¼ could not write their names legibly. Nearly 10 per cent had never gone beyond the first grade and considerably more than half were in the fourth grade or lower when they left school. Only about 3 per cent were in eighth grade and about one in a hundred had reached high school. These children were native Americans.

Dispatch from Stockholm states that Karlsborg Radio Station, largest in Sweden, which has lately begun service with many countries, including regular communication with England and Germany, will establish a regular service with America upon completion of a test with an American station outside New York.

Efficient Organization of Power Plant Help---II

Duties and Responsibilities of Central Station Operators. By H. A. Wilcox

DIRECTLY under the chief engineer of the central station, come the watch engineers. They are the eyes, ears, and nose of the system and can do more toward building up and maintaining an efficient organization than any of the other men can. This may seem at first glance, to be a rather broad statement. Let us prove it in a few words.

The watch engineers supervise the direct detailed operation of the machinery and it is their duty to see that everything is kept at all times in proper running order. The chief, due to his numerous duties, cannot come into quite as intimate contact with the men and machinery as the watch engineers can. He therefore depends upon the engineers to watch the details. He, the chief, knows whether his plant is running properly or not from the daily reports of his engineers. If these reports are clear and comprehensive, he can keep himself in close contact with his plant by a close scrutiny of the reports and a walk around the plant several times a day. If, on the other hand, the engineers turn in careless and "faked" reports, to cover up their own inefficiency and laziness, some day a bad break-down will occur which will put the plant out of business for a while. The reports of the engineers should in general, cover the following items: Fuel consumed per shift; fuel received; feed water evaporated per shift; oil and supplies used per shift; hour operation of boilers and engines; feed water temperature; weather; condensing water temperature; average steam pressure; average vacuum; oil temperature at bearings, if turbines are used; flue gas temperature; average per cent CO_2; number of men absent; and finally, but very important, the work done and minor repairs made during the shift. Under "remarks" as the last item, notes should be made of anything unusual occurring on a shift and of any major repairs which are at present needed or will be necessary in the near future.

From such a report the chief can figure the efficiency of his plant; the amount of fuel he has in reserve; and can plan out work for the repair gang and will know that his machinery is in efficient condition at all times. A comparison of the reports from the different shifts, usually three, will demonstrate which shift is doing the best work. The inefficient shifts can then be stimulated to do better work to equal the example of the best.

To demonstrate the value of accurate reports, let me cite an example. I have in mind a textile factory superintendent. This man sits at his desk all day long and studies the reports of his lieutenants. About twice a week, he walks all over his plant and makes notes of things he sees on the backs of old envelopes. In due time, his subordinates receive letters, giving orders, praise, or a "jacking-up" with regard to affairs in their charge. What is the value of the letters? Well, the subordinate cannot argue and offer excuses to a letter and waste his own and the "super's" time that way. The letter states clearly just what is wanted and there is no chance for mistakes or misunderstandings.

The super is able to study the subordinates' reports unbiased by verbal explanations or excuses. He has the reports for future reference. He has more time for planning the larger affairs of his plant. If an occasion arises where reference to him is absolutely necessary at once, the super can always be found at his desk, without delay, unless he is on one of his tours of inspection. The regular inspections of course serve to check up the subordinates' reports and anyone from the highest to the lowest paid man in the plant has the privilege of taking up any matters of personal interest with the super during his inspection round.

A few more words as to the watch engineers' duties and we will leave them for the oilers, etc. In any large plant, it is generally customary for the outgoing shift to leave things in good order for the incoming shift. Each watch engineer should carefully see to it that his oilers, firemen, etc., leave everything right—full oil cups, full grease cups, machinery well oiled and cleaned; ash pits clean; fires cleaned; boiler fronts wiped off, etc. He should also give the incoming watch engineer a few pointers on anything that needs watching, such as hot bearings; leaky pumps, etc., that may have developed on his shift; or any minor repairs which he thinks the incoming shift should make. In other words, apply the spirit of the Golden Rule, Mr. Watch Engineer: Leave everything in as good condition as you would like to have it left to you, and if the shift which precedes you doesn't leave everything just right, don't grumble and "squeal" to the chief and leave your work slighted. The chief will find the other shift out sooner or later and will think more of you for doing your best without grumbling about the other shift.

In these small things, the orderliness and efficiency of the plant is maintained or destroyed. To my mind, one of the worst things an engineer can do is to "pass the buck" or lay the blame on the other fellow, as an excuse for slighting his own work. I can find out when the "other fellow" is shirking and replace him with a better man, but it is very hard to build up a "pull together" organization when each man is blaming the other one as an excuse for his poor work and I get going around in circles from one to the other until I have to fire the whole bunch and start afresh.

The oilers, firemen, coal passers, and ash men are the arms, fingers, legs, and feet of the organization. They carry out the details of the actual operation of the plant.

The oilers watch and oil the bearings; keep the machinery clean; make minor repairs, under the direction of the watch engineer; in many plants, actually start and stop the machinery; and take the various readings from which the watch engineer makes his daily reports. They should at once report anything of an unusual nature to the engineer and do as he tells them. By studying his decisions; talking with him and assisting him to the best of their ability, the oilers gradually learn enough so that they become competent to take a position as watch engineer. In many plants, the senior oiler becomes watch engineer when a vacancy occurs. By doing all their work their very best and leaving things in

proper condition at the end of their shift, the oilers can maintain the reputation of their shift for orderliness, efficiency, and neatness.

The major duty of the fireman is to maintain the proper steam pressure at all times. In a plant in which the engineer can always rely upon the fire-room for furnishing the steam at all times, at the proper pressure, things generally go smoothly. When, however, the engineer has to leave his reports, repairs or other work two or three times per shift and "jack-up" the fire-room because the pressure has dropped, he very naturally gets "grumpy" and perhaps gives the oilers a little dose for good measure. This discontented spirit soon goes through all the men on the shift and work is slighted; result—an inefficient shift. Give the engineer confidence in the fire-room and he will lighten the firemen's work by running his engines at their most efficient points; stopping steam leaks around the plant, and cutting out all but the boilers necessary to maintain the required pressure. Mr. Fireman, keep up the "pull together" spirit at the plant also by leaving clean fires, clean boilers and clean ash pits for the incoming shift. Remember that the other fellows have just come in from outside and it is pretty hard to go at hot, dirty fires and bring up a low steam pressure the minute you go to work and before you have had time to get your bearings.

Firemen should always bring necessary boiler repairs to the attention of the engineer at once. The boilers are the "heart" of the plant and *must* be kept in the best condition at all times. Remember, also, that a dirty, slovenly fire-room often means tubes covered with soot, scaly boilers, and steam leaks. The firemen handle anywhere from $50,000 to several hundred thousand dollars of the company's money every year, in the form of fuel, depending upon the size of the plant. They must therefore try to handle this fuel in such a way as to produce the most steam for the least possible expenditure of fuel. In other words, a dirty fire-room and dirty boilers do not walk hand in hand. Regularity is a great help also. Don't fill the furnaces full of coal and expect that you can sit down and take things easy until the coal burns out. You don't feed your stomach that way, or if you do, you feel stupid and sleepy. Therefore don't feed the boiler's stomach that way. Be regular in blowing down the boilers and water columns and in cleaning the tubes and washing the boilers. In that way you can always be sure the work is done. Also, don't feed poor coal to your furnaces if you can avoid it. You don't eat poor food yourself, if you can help it. If you get a lot of coal that seems to be of a poorer grade, call your engineer's attention to it and be guided by his advice. In nine cases out of ten, he has been up against the same thing himself and probably knows more about it than you do, or he wouldn't have risen from fireman to engineer. If you do get poor coal, don't tell the engineer "bum coal" as an excuse for low steam pressure. He may have worked that gag himself when he was firing. If you do your very best, he will help you in every way he can and will try to get those above him to get a better grade of coal for you.

A few words only will suffice for the coal passers and the ash men. The names explain their duties and more is unnecessary. They should, however, remember that all the coal which they put in the fire-room has to be handled again by the firemen in front of hot fires and thrown a distance of from 6 to 8 ft., whereas they have a cool, though perhaps dusty place to work in and have to throw the coal only a little way. In addition to feeding the fires, the firemen also have to clean them, and a helping hand here always results in a better spirit in the fire-room.

Ash-men, remember that a fireman has a hard time of it, anyway, so get those hot clinkers out of the way as soon as possible and keep the pits cleaned out to help save the grates. Don't get in the fireman's way when he has the fire door open and make him leave it open longer than is necessary. He knows that an open fire door means poor economy and harder work for him to keep up steam, so he isn't likely to bless you for it.

Let us again quote the Golden Rule in another way. "Help the other fellow all you can and he will help you." This makes for a good, coherent, efficient organization and, in nearly every case, the man above you will help you to get up the ladder so he can advance another step himself.

In a stoker-fired plant or a plant where oil fuel is used, the remarks on coal-passers and ash-men are in most cases unnecessary, as their services are usually not required.

There are two main branches generally under the chief engineer in large central stations which have not been touched upon as yet. They are the repair gang and the electricians.

These two departments should work hand in hand with the watch engineer. The electricians should handle the load in such a way as to make the least possible demand upon the engines. They can do this by keeping the generators, rotaries, transformers, switches, etc., clean and well oiled; by cutting out the street lighting load at exactly the right time each morning, not 10 min. late, or put in 10 min. early; by keeping the voltage at the proper point, not five volts high so they can sit down and read the paper; and by loading up each machine to its most efficient point and shutting down unnecessary units. An electrician handling the high potentials in use nowadays must proceed slowly and *think* his way along, even though he has done the same thing every day in the same way. He must remember that, although steam is quick, the engineer usually has a second chance, but that electricity is chained lightning and the first guess must *always* be the *right one*. There are no "second chances" with electricity.

The electrician's report is quite as important as the watch engineer's. It should embody the weather, hour operation of generators, rotaries, etc.; loads on the different main circuits all through the shift and under "Remarks" any unusual occurrences and repairs needed or made. By checking this report against the engineer's, the chief locates mistakes in either; knows his load curve and the location of the peak loads; notes whether its reserve capacity is being encroached upon or not; and knows the physical condition of his electrical machinery.

Comments upon the leaving of the apparatus for the next shift apply to the case of the electricians in the same manner as to that of the watch engineers.

Finally, the repair gang; they undertake the major repairs which cannot be made by the watch engineers. There is generally only one repair gang and, if necessary,

they must work at times 24 hr. or more at a time. They generally have full charge of the fuel handling, machinery, both as to maintenance and operation, in a stoker-operated plant. The duties of the repair gang are too manifold for enumeration here, but suffice it to say that they usually range from soldering an oil can to completely overhauling one of the generating units or engines. They should work hand in glove with the watch engineers in every way. If they have to pack a valve that they think the watch engineer should have packed, do it cheerfully and without grumbling, as the watch engineer may have had other things to think of on his shift and couldn't do it. Another thing, remember that the oilers have to keep the machinery clean and the less dirt you make and fewer times you put your greasy hands upon polished surfaces, the easier their work will be and the better they will like and help you.

Always try to make all your repairs in the best possible and most permanent way. Then the engineer can devote his attention to operation and help you with minor repairs because he won't have to worry as to whether your repair job will hold or not.

Finally, remember that the repair gang sees more of the inside of the machines than the other men do. Therefore, keep your chief engineer well acquainted with the entire physical condition of the machinery so he can plan for replacement. If a job is too big for you to handle properly, don't "patch it up"; call on the chief for outside assistance. When repair work is light, don't hide in corners; give the operating shift a hand; it won't hurt you; they may help you some day, and you may learn something from them that will help you later on.

We have now gone over the duties and responsibilities of the force of the average central station pretty thoroughly. The titles, duties and work vary somewhat in different plants, but they are very similar in well-managed stations. We can therefore now leave the central station and pass on to the consideration of the power plant of the industrial type. In the main, the duties and responsibilities of the men are identical with those of the central station men. We can therefore accord them shorter treatment and will confine ourselves to a more concrete statement of their duties and show where their responsibilities differ.

Bolshevism Versus Loyalty

By Jack Ball

"BOYS," began the Chief, "I was just thinking on my way here tonight about Bolshevism. I am wondering what kind of a country Russia really is. Anybody in the crowd know?"

A respectful silence was our answer.

"Suppose that we jump across to the United States," he continued. "Right now the labor of this country is being inoculated with radical germs of dissatisfaction and unrest. The steel and coal industries have been paralyzed. We won't question the rights of either side, but we have been at our wits' ends to keep the flywheels turning over. We thought we had a taste of trouble; we did. If we multiply our industrial unrest by one hundred we will have a second Russia.

"It is a fact that the engineers are about as loyal a bunch of men as we have today. Again, the public knows very little about us and is too busy to make an acquaintance.

"Now, I do not believe in the theory—such as artists and musicians have—that engineers are born; but I think that in most cases their training starts early in life. You will find, too, that the fellows that have stuck and are successful are men that love their work. It makes no difference whether we art putting a link in a stoker chain or shifting a 10,000-kw. load from one turbine to another, the job is a pleasure and we derive a feeling of satisfaction both in the execution and on the completion of the job.

"In the business world, nowadays, a man is hardly considered a success until he has acquired a million dollars or so. It is different with us. I have seen engineers who have failed to operate a 100-hp. plant without trouble and shutdowns. The next fellow that came along and took the job did not look at the job with a sad and downcast look; instead, he rolled up his sleeves, dug in and rooted out the trouble. After he had things running to his satisfaction he washed the windows, swept the floor, cleaned the bright work, built a work bench, tool board and other things during his spare time. He got a raise in pay two or three times. You fellows know who I've got in mind—Billy Green, over at the handle factory. Bill has a small plant and we know that he is a success."

"What's that got to do with the Bolsheviks?" interrupted Sid Malone. "A man has to work hard at anything to be successful."

"That is true," answered the Chief. "If a man is digging a ditch he uses his muscles for the most part. He doesn't give a thought, probably, nor does he care, whether the ditch is to hold water, tile, sewer pipe or a gas main; he does not care whether the tools he uses are made of iron, steel or copper. He is giving more thought to quitting time and his wages.

"Now, consider the engineer: He should have adaptability and a heart interest in his work. This will cause him to study every phase of his vocation, from the composition of coal to computing the horsepower of his 3-phase alternator. He is learning something new every day, either from practice or study. Furthermore, he is willing to do anything at any time to make his plant more reliable and efficient. If he is true to his calling he considers his plant an integral part of himself and is going to make good. You see, boys, that all the Bolshevik literature in print isn't going to interest him. He is as loyal as you find and is poor picking for the 'soap box orators.'"

The Sweet Young Thing who had been shown around the power house told the general superintendent that his foreman was certainly a very kind and humane gentleman.

"Yes, he is a splendid fellow; but why do you give him such an excellent recommendation?"

"Well one of the men told him that an old girl was full of scale, and asked him what to do, and he ordered that she be given a good bath, blown out, and then, too, that she be dressed up."

The telephone rang at this moment, and Mamma called the S. Y. T.

E. G. BAILEY

ONE OF AMERICA'S FOREMOST FUEL ENGINEERS. A STUDENT OF BOILER ROOM PROBLEMS WHO HAS DEVELOPED METHODS OF BOILER CONTROL. BY ROBERT S. COFFIN

FEW men have so well understood the perplexing problems of the boiler room or have contributed so extensively to the practical solution of combustion problems as E. G. Bailey. His whole life has been devoted to a study of fuel engineering in its different aspects. He has covered it from the ground up—the mining of the coal, its chemical analysis, the firing of boilers and the operation of boiler plants—in all of which he has been not only a close student but an experienced workman, and as a result has been able to furnish that practical knowledge by which steady, efficient and profitable production of power can alone be maintained.

As a boy in his father's sawmill at Damascus, Ohio, Bailey received his first lessons in boiler room practice as he stoked the old boiler with green slabs and sawdust. And the way he made that boiler hum was but an omen of what he was later to accomplish, in a more scientific way, in the great power plants of the country.

In 1898 he entered Ohio State University, where he had the good fortune to study the analytical side of fuels under the late Professor N. W. Lord, and their practical use in the boiler room under Professor E. A. Hitchcock. It was undoubtedly the influence of these men, enthusiasts in this field, which assisted him largely in making his decision to take up fuel engineering as his future vocation. As a student he was "everlastingly at it," not only carrying with success the prescribed work laid down in the course of mechanical engineering, but at the same time doing much outside work, calling for long hours and iron-clad endurance. He graduated with credit to himself and honor to his university.

About the time he completed his course the Consolidation Coal Co., of Fairmount, W. Va., was looking for a young engineer familiar with boiler room practice to take charge of tests and complaints on steam coal in the plants of their customers, including also work in the sampling and analysis of coal from numerous mines. Bailey was selected to fill the position. It covered the field from the sampling in the mine to the generation of steam in many stationary boiler plants as well as on locomotives and steamships. Once he went as far as Buenos Aires, South America, to conduct some tests in competition with British coal.

This experience and his familiarity with coals in general soon gained for him an enviable reputation as a coal authority. In 1907 he resigned from the coal company to accept a position as head of the coal department of Arthur D. Little, Inc., Boston, Mass., and in 1909 he established the Fuel Testing Co. for coal analysis work and the treatment of boiler room problems.

Up to that time, no reliable method had been found whereby the clinker-forming properties of coal could be predetermined, nor had it been possible to make comparisons of this characteristic in different coals. Even the complete analysis of the coal ash itself did not disclose its clinkering properties. He exploded the prevalent opinion that the percentage of sulphur in the coal could be taken as a reliable indication of its clinkering tendencies. After careful study and experimentation, Mr. Bailey discovered that there was a definite relation between the percentage of ash that fused into clinkers and the fusing temperature of the ash itself. This was a noteworthy discovery and one of far-reaching importance to power plant operators.

In his fuel engineering Bailey discovered what health specialists were teaching in regard to human efficiency—that it is not a matter of how much one eats, but rather how he eats it; not how much exercise one takes, but the methods used. Applying the same principle to the boiler room, he was insisting that the important factor was not the quantity of coal being consumed and the evaporation per pound of coal obtained, but the extent of the controllable heat losses and how they could be reduced; not what style of equipment was being used,

but rather how it was being operated. He had found elaborately equipped plants burning the best quality of coal and yet producing only a fraction of the results of which they were capable, largely because the fireman had no reliable means for determining the true condition of the fires and, as a result, believed he was getting out of the equipment all that it was capable of producing. Bailey recognized that it was vital to efficient boiler operation for the fireman to know just what was going on inside the boiler and furnace, and not resort to guess work. It was his broad experience in the laboratory and boiler room and the knowledge gained of the viewpoint of the boiler room foreman and fireman that made him fully realize the great importance of simplicity in boiler room recording apparatus—something easy of interpretation, something which would tell the story at a glance—a principle to which he has adhered in the development of boiler room appliances.

His extensive knowledge of fuels, coupled with his good judgment, brought him into public prominence in connection with coal problems. He served on the Fuel Supply Committee of the Boston Chamber of Commerce, which made an exhaustive investigation of New England's coal supply and in this connection contributed much valuable data which enabled coal consumers in that section of the country to effect appreciable economies in their fuel bills. As a member of this same committee, he was largely responsible for the preparation of the sensible plan underlying Boston's smoke abatement law, which has since been used as a model for many other communities.

In 1917-1918 he was selected by The Johns Hopkins University as one of the lecturers in the "J. E. Aldred Lectures" on engineering practice. He chose as his subject "The Coal Problem," for it was just at that time that our fuel difficulties reached an acute stage and threatened to endanger seriously our war activities.

He is serving on various committees of the American Society of Mechanical Engineers and has contributed valuable papers on fuel engineering subjects for the A. S. M. E. Journal and the leading engineering publications. His articles on "Draft in Furnaces and Flues," "Steam Flow Measurement," "Measuring Water with a Weir Meter" and others are recognized contributions on these subjects.

In 1916 he launched the Bailey Meter Co., of which he is president and general manager. Although but three years in existence, his company has had phenomenal success.

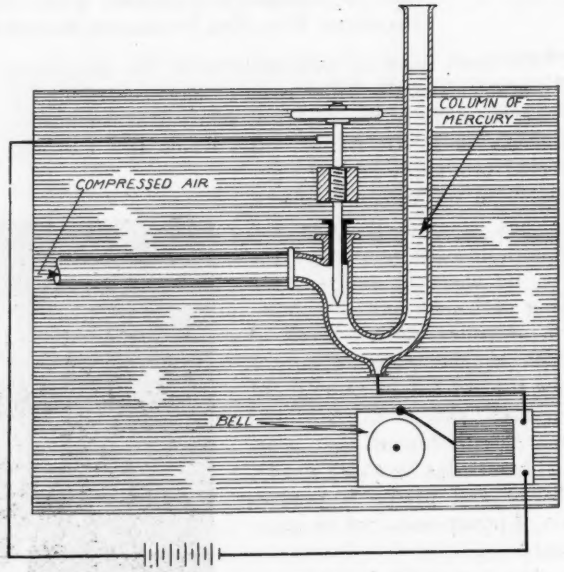
Mr. Bailey is not only a creative genius, but has demonstrated that he possesses rare qualities as a business executive. He has a keenness of perception that immediately gets beneath the surface and grips the essential facts, and as a result he wastes little time in sizing up any proposition that is submitted to him. He possesses a courage and determination that are bound to spell success in any line of endeavor.

If asked whether he would prefer to be popular, or wealthy, or distinguished like some of his contemporaries, he would probably ask for none of these. He would ask to be efficient. Efficiency is what he looks for in his associates and employes and what, with even greater insistence, he asks for in himself.

Compressed Air Alarm

By J. H. Blakey

FOR certain industrial purposes, it is necessary to keep air or gas under pressure. Sometimes the system in use is such that the pressure may fall considerably without attracting the attention of the attendant. In Germany, a simple arrangement of a U tube and an electric bell has been put in operation in many plants. The height of the column of mercury



APPARATUS FOR COMPRESSED AIR ALARM

necessary for a given pressure will be about 2 in. for each pound, as the atmospheric pressure at sea level—14.7 lb. per sq. in.—supports a mercury column 760 mm., or 29.4 in. in height.

Pump Troubles

Some time ago I had charge of a battery of eight boilers and two duplex pumps. We were pumping our water from a pond or lake. This water was run through a filtering process, into a hot well, thence to the pumps and into the boilers. We had a great deal of trouble with scale and mud in the boilers at all times, and one pump was giving us a great deal of grief. This pump would work well at times; at other times it would deliver only about one-half the supply.

We examined the valves, packing and did everything we knew of to locate the trouble, and were on the verge of discarding the pump when one fine day I decided to look over the pump once more. As soon as I removed the air chamber, I discovered the cause of the trouble. A scale or lime substance had formed on the valve stem and had worn perfectly smooth, yet large enough so that if the valve did not lift properly, it would hang up for a time. I was fortunate enough to catch it in the act. The scale was noticed when I tapped the valve stem to seat the valve; small particles fell away from the stem. If any of our readers are using water from a pond or lake and having trouble with the pumps, this experience might help them.

R. Gordon.

Coat the Boiler Setting

A Study of Some of the Important Losses in the Power Plant. By H. M. Brayton

WE HEAR and read a great deal these days about efficiency. We are told that this is the age of efficiency and that if we would get along in this world we must practice it in every phase of our daily life. The word *efficiency* has been much abused. We are told that an organization is efficient if it does good work and that the city government is efficient if it keeps public expense down to a minimum. Efficiency should be defined merely as the ratio between the work accomplished and the effort expended to produce that work. Such is the definition which we give to this word in engineering.

During the last few years there has been a general movement on foot throughout our country and, in fact, throughout the world, to increase the efficiency of power plants. This movement has been aided by the constantly increasing price of coal, by competition which manufacturers have had to face, making it imperative for them to reduce the coal bill to a minimum and last, but far from least, the spirit of patriotism brought out so admirably during the war, when the conservation of coal was a national duty.

Much has been written on how to increase the efficiency of the boiler. Better methods of firing have been introduced as well as improved ways of treating the feed-water. Heat has been saved at every turn through the introduction of better feed-water heaters, economizers, etc. Firemen and engineers have been educated to the new conditions through pamphlets and lectures. The combined results have been truly wonderful.

There is one phase of the subject of boiler efficiency which seems to have been neglected by most of the writers. This seems strange in view of its importance and also in view of the fact that the remedy is in almost universal use today. We refer to the boiler setting and the means employed to seal it against leakage.

The Boiler Setting

The externally fired boiler must, of course, have a brick setting which incloses the combustion chamber. This setting is at least 4 to 6 in. in thickness and usually supports the boiler itself. It is made from ordinary red brick, but lined with fire brick to resist the heat of combustion. The boiler should be mounted so that expansion and contraction of the steel drum will not bring undue strain on the brick work. Provision must also be made for the brick wall to expand when the boiler is in operation.

Brick is porous. If the reader doubts this statement, let him take a new brick, weigh it carefully and then soak it in water. After this treatment, weigh it again and note the increase. If a brick is porous to the extent that it will absorb water, is it not logical to believe that air will pass through it? When the boiler is in operation, we have the ideal conditions for this to take place. The chimney creates a draft, which means a pressure over the fire of less than atmospheric. The pressure on the outside or in the boiler room is atmospheric. Naturally, air will flow through the brick under this difference of pressure.

To insure proper combustion, we must admit just the right amount of air into the ash pit. Every engineer knows that the air should be made to pass up through the fuel bed. Sometimes we get an increase in efficiency by admitting air through the feed door. In either case, the air enters the combustion region where the temperature is high and therefore where it is possible for the air to unite with the carbon of the coal and form the much needed carbon dioxide (CO_2). But suppose we admit cold air from the boiler room at a point beyond the combustion range where the gases have been cooled to such a point that even if clear particles of carbon or unburned carbon monoxide (CO) are present, union cannot take place; in such an event, the air would do a great deal of harm by cooling the gases. The air from the boiler room, even if it does seem very hot to the fireman, is really cold when compared with the flue gases.

Such is the case when air leaks through the boiler setting. The efficiency of a boiler does not vary directly with the temperature of the flue gases, all other factors remaining the same; that is, we cannot draw the conclusion that if we increase the temperature of these gases 20 per cent, the boiler efficiency will also increase 20 per cent. As a matter of fact, the increase in efficiency will be greater; this is due to the fact that the rate of heat flow through the tubes of the boiler increases rapidly as the difference of temperature between the gases and the water increases. The reverse is also true; if we lower the temperature of the gases, the loss is in greater proportion. It stands us in hand, therefore, if we would be good engineers and firemen, to make every effort to keep this cold air from the combustion chamber.

How to Prevent Air Leakage

Air leakage through brick walls can be entirely prevented by coating the brickwork with a plastic cement made especially for this purpose. This product is not an experiment, as it has long ago passed out of the experimental stage. There are several good reliable manufacturers of this material which may be had either in the black or red and is a heavy plastic cement. It is applied to the brick setting with a trowel and should be put on about ⅛ in. thick. The cement is very sticky when applied. The heat of the setting soon hardens the cement to a certain degree, yet it never gets so hard that one cannot insert the thumb nail. The reason for this is obvious. If the cement became hard, it would very soon crack and chip off under the expansion and contraction of the setting. Most makers will guarantee their cement to seal the boiler perfectly for at least 3 yr.

How Boiler Setting Cement Pays for Itself

It has been found from very extensive tests that the air leakage through a new brick setting was sufficient to cause a loss of 3 per cent in the coal. If, then, we coat our setting, we cut our coal bill by that amount. In addition to the loss due to air leakage, the cement, being an asbestos material, prevents heat radiation

through the wall, just the same as the covering on your steam pipe. This saving is often considerable. It is not unusual to have the setting so hot that one cannot hold his hand on it. The coating keeps in a lot of this heat, all of which tends toward a more efficient boiler.

Thus far only a new setting has been discussed. Everybody familiar at all with the boiler room knows how a setting will crack and break down under the heat and the constant expansion and contraction. Cracks develop in a zigzag fashion which often extend clear through the wall; these cracks are sometimes large enough to allow the finger to enter. Large volumes of air naturally enter through these cracks and the loss is often extreme. A lighted candle held up to these cracks will often be drawn out, due to the heavy draft. Not only does this lower the temperature of the gases, but the cold air striking directly on the hot tubes causes unequal expansion, and sooner or later tube trouble will result.

Air leakage of this kind greatly lowers the available draft and it becomes more and more difficult to maintain the fire. When a hole is once started through the setting, the constant passage of air enlarges the opening and the decay of the setting is progressive in the geometric ratio. All this can be avoided by coating the setting when new. Many engineers feel that when the setting is new, it is tight and does not need to be coated. They prefer to wait until it develops cracks, when the immediate saving will be more. This is a mistaken idea. The old adage, "A stitch in time saves nine," applies well here. The life of the setting will be greatly increased by applying it to a new setting and even at the 3 per cent saving in coal, the material will pay for itself in a short time and will earn a good return on the investment.

When settings start to develop cracks, the troubles of the engineer begin. He is compelled to go over them and fill up cracks about every 6 mo. or let them leak. Most engineers know what such cracks will do to the coal pile and make every effort to fill them up. There are a few exceptions, however, as the writer was talking with one engineer not long ago who seemed to lack this fundamental knowledge. He was in charge of a plant which consumed 150 tons of coal a month and every one of his settings contained cracks large enough to take the whole thickness of the hand. In some cases the draft was sufficient to draw out the flame of a candle. In the face of the facts, the engineer in charge claimed that his settings did not leak because he kept them in good shape. He further stated that even if a coating did save 10 per cent of the coal, he could not tell it. Maybe he couldn't tell the difference, but the one who paid the bill certainly could at the present price of coal. He thus admitted his own inefficiency and showed his lack of knowledge in his own profession. Such a man should not be given charge of a boiler plant. He is a drag to progress. Fortunately these men are rare.

Cost of Coating the Setting

One of the first things that the efficient engineer wants to know in connection with the coating of the setting is its cost; not necessarily the actual cost in dollars, but the cost in proportion to the amount of coal saved. In other words, how good an investment will it be? Men are coming more and more to look upon all expenditures of this kind as investments and that is the proper way. The present cost of this coating is about 12 cents a pound. Usually it requires about 40 lb. to 100 sq. ft. of surface. This figures about $5 per 100 sq. ft. exclusive of the labor item which is small; it is often possible for the engineer or fireman to put it on in his spare time. Usually these men are more than willing to put it on if by its use they can show a saving.

On a new setting, one can figure a 3 per cent saving. On a very old and badly cracked setting, the saving procured from coating it may mount as high as 15 per cent. On old settings which show a few cracks, it is safe to assume an 8 per cent saving. With these facts in mind, it is a simple matter to calculate the saving per month when you know the amount of coal you burn and the price you pay for it. For illustration, let us assume that a certain power plant required 600 lb. of the cement. The total cost would be $72. We will say that the plant burns 50 tons of coal a month and that this coal costs $5 a ton; total coal bill, $250 a month. Even if the saving was but 5 per cent, we would have a saving in the coal bill of $12.50 a month, or $150 a year. At this rate, the saving would pay for the coating in 6 mo. Looking at it in another way, we can say that an investment of $72 would net a return of $150 each year, which represents over 200 per cent. Any intelligent person would consider this a good investment. These figures are all very conservative and in many boiler plants the saving is greater in proportion to the investment. These cements will seal the boiler for at least 3 yr.

Forced Draft

When forced draft is used, it is usually regulated so that there is atmospheric pressure over the fire. Under this condition, there is less tendency for the outside air to pass through the brick work. It is never possible to balance this draft perfectly, however, and in the last passes of a water tube boiler the pressure is sure to be lower than outside. Even when the draft is balanced the saving from the radiation is still present as well as the preservation of the walls. It has been the writer's experience that it paid well to coat the boiler which had forced draft although not as much as with natural draft.

How to Determine Saving

Many engineers want to know how they can tell a saving even if present when their load fluctuates greatly from day to day. It is true that it is more difficult to determine anything under such conditions, but the law of average should work it out all right. This might require a record over a long period of time. A better way would be to keep a careful record of the flue gas analysis and compare it with a similar analysis taken after the cement was put on.

The leakage of air through the brick work cools the gases in the combustion chamber. This prevents the oxygen from uniting with the carbon to some extent and the result is a lower percentage of CO_2 and a higher percentage of CO. The longer the gases can be maintained at a temperature above that required to unite carbon and oxygen the better efficiency we obtain. We should then obtain the percentage of CO_2 and CO and from these values work out the efficiency or per cent of heat lost. The following problem will illustrate how this

is done and will enable the engineer to work this out for himself. An Orsat apparatus for obtaining the analysis is all that is needed.

Let us suppose that a certain analysis showed the following data: $CO_2 = 13$ per cent, $CO = 0.8$ per cent by volume. We shall apply the method of vapor densities. The vapor density of a compound is just ½ its molecular weight. We have then for CO_2 a vapor density of 22 and for CO a vapor density of 14. In every 100 cu. ft. of flue gas of the above analysis we would have the following weights based upon hydrogen as unity.

$$13 \times 22 = 286 \text{ for } CO_2.$$
$$0.8 \times 14 = 11.2 \text{ for CO.}$$

Each pound of CO_2 contains 3/11 lb. of carbon and each pound of CO contains 3/7 lb. of carbon. These figures are obtainable from the molecular weights as follows: The molecular weight of CO_2 is made up of

$$12 + (2 \times 16) = 44$$

The carbon in this compound consists of 12/44 or 3/11 of the whole.

Then with 13 per cent of CO_2 representing a vapor density of 286 we have

$$\frac{3}{11} \times 286 = 78$$

parts of carbon and of the 11.2 parts by weight of CO we shall have

$$\frac{3}{7} \times 11.2 = 4.8$$

parts of carbon. The total weight of carbon will be

$$78 + 4.8 = 82.8$$

Efficiency of Combustion

Now, 78 parts of carbon when burned to CO_2 gives up

$$78 \times 14{,}650 = 1{,}142{,}700 \text{ B.t.u.}$$

and 4.8 parts of carbon when burned to CO gives

$$4.8 \times 4{,}400 = 21{,}120 \text{ B.t.u.}$$

which makes a total of

$$1{,}142{,}700 + 21{,}120 = 1{,}163{,}820 \text{ B.t.u.}$$

If all the carbon had burned to CO_2 we would have the maximum possible efficiency of combustion as follows:

$$82.8 \times 14{,}650 = 1{,}213{,}020 \text{ B.t.u.}$$

The loss from incomplete combustion is then

$$\frac{1{,}213{,}020 - 1{,}163{,}820}{1{,}213{,}020} = 4.06 \text{ per cent.}$$

When expressed by an easily used formula, the loss in per cent due to incomplete combustion is equal to

$$\left(1 - \frac{CO_2 + 0.3\,CO}{CO_2 + CO}\right) \times 100$$

From this example it should be clear that one can not determine the loss due to poor combustion from the percentage of CO_2 alone. We must also have the percentage of CO present. If the engineer will take the trouble to make a flue gas analysis every day for a month, average it and work out the per cent of loss according to the above method or by reference to the tables and charts given in the January 1, 1920, issue of Power Plant Engineering, he can quickly tell whether or not the application will tell the story. The saving shown is of course not the whole story because the saving from keeping down the heat radiation through the walls is a separate item.

The best way to obtain the absolute saving is of course to run an evaporation test. This is seldom practical on a commercial plant. It usually requires a trained man to conduct such a test. Unless care is exercised the results obtained are of no value. The method outlined above of obtaining the saving from the use of the cement coating is practical in nearly every plant, is easily applied and requires no expert to carry it out.

Unusual Conditions

It often happens that there is a lack of room when the boiler is installed. It is not uncommon to see a boiler setting built right into the wall. The writer has even seen a boiler completely surrounded except at the front by building walls. Such a condition means, of course, that one can not get at the brick work at all. Should cracks develop there is no remedy. A still worse condition is where the setting is placed just a few inches from the building wall. There is not room enough to get between and yet large cracks can form through which air can enter the combustion chamber with the engineer powerless to prevent it.

Even in the early days, the necessity of preventing air leaks through the setting was recognized. The writer was recently in a plant in which the settings had been placed a long time ago. The setting consisted of three walls with a 4-in. air space between them. The inner wall carried one side of the boiler. Then came an air space, then another wall, then another air space and finally a third wall. Obviously, very little air could seep through such a setting and the owners have little use for a coating.

Another method of preventing air leaks through a setting has been used, which consists of placing tight to the outside of the brick work a sheet of steel or iron. The wall should really be built against it because if an air space existed between the two surfaces, the steel plate would be worthless.

The up-to-date engineer must show good efficiency in his plant; to do this, he must keep the boiler settings tight. The man who pretends to be a good engineer and yet does not take care of this fundamental requisite in the boiler room will sooner or later fall by the wayside and be replaced by a more modern and more scientific man. The world has no room for the engineer who does not progress with the times.

At the Convention of American Association for Advancement of Science, according to the Associated Press, it was stated that Professor F. S. Lee, of Columbia University, outlined results of an investigation to determine the most effective method of stimulating production by proper use of physical power of workmen. In studying physical industrial conditions to develop accurate rules by which production can be enlarged, tests have been made in factories showing effect of holidays on employes, effect of rest periods and effect of long hours on the number of accidents.

Let mules do the kicking.—Forbes Magazine.

Efficiency in the Oil Room

A Modern Oil Handling System Saves Time and Oil, and Reduces the Fire Risk. By C. H. Davies

PRESENT conditions emphasize the importance of conservation and efficiency, but it seems as if the subject of conservation of time, material and labor in the storage and handling of oils, has been overlooked by many plants that are otherwise modern. In these days of close cost accounting, it is important that some system be provided for the proper and economical receipt, storage, distribution and checking of oils and similar liquids. Managers and superintendents that pass over their wasteful oil room conditions with a wave of the hand and a remark that "We don't lose much" might be surprised if they stopped to investigate conditions. Thousands of dollars are deliberately thrown away each year because of these losses, due to inadequate storage and dispensing facilities.

FIG. 1. TIME IS LOST BORING FOR THE TAP. THE MAN ON THE RIGHT DOES NOT BELIEVE IN SIGNS

Oil as a lubricant is an important factor in successful commerce. Maximum efficiency in lubrication can be obtained only by securing the right oil for each class of service and handling the oil properly. Handling oil properly means protection against waste from leakage, spillage, defective containers, non-drainage of barrels, carelessness and unauthorized removal. It means to provide for accurate checking of receipts, recording of withdrawals, convenience, speed in handling, a reduction of labor, and absolute protection against contamination with dirt and other impurities.

In modern storage systems, the oils which are received in barrels are emptied by gravity into leakproof storage tanks, thereby eliminating loss of oil on account of leaky barrels. The gage tells the approximate number of gallons contained in the tank, thereby checking up short barrels and invoice mistakes. The one-man method of emptying barrels with cradle, track and dash, drains the barrel absolutely, and eliminates the loss due to oil being left in the bottom of the barrel. Storage in steel tanks eliminates the absorption loss incidental to storage in wooden barrels.

Where faucets are used to draw the oil, there will be leaking faucets and over-run measures, and consequently loss of oil.

Increases Cleanliness and Reduces Fire Hazard

Modern equipment provides cleanliness, efficiency and economy. There will be no oil-soaked waste, no oil-

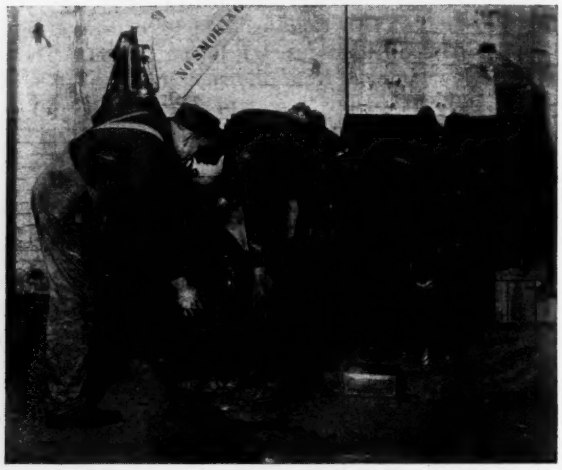


FIG. 2. MORE TIME AS WELL AS OIL IS LOST IN RIGHTING THE BARREL

coated floors, no dripping faucets or dirty funnels and measures. All of the oil will be either in the equipment or in use. There will be no waste. This class of equip-

FIG. 3. WAITING FOR THE CAN TO FILL—AND POSSIBLY OVERFLOW ONTO THE FLOOR

ment is made in strict compliance with the requirements of the National Board of Fire Underwriters, and through its use there will be a material reduction in the fire hazard.

In both wooden barrels and tin containers, you always have the wasteful faucet and molassesgate with which to contend.

Modern oil systems are made to fit individual needs, each unit being made of the same height and depth, and larger storage provided by increasing the width of the individual tank unit. You can readily see that this way of handling oil storage gives an elasticity for expansion as business increases, with the greatest economy of space.

The saving in handling oil in a modern system over the old method hardly needs argument. Whether there is a single unit or a battery, no funnels or measures are used. The oil is transferred from the tank directly into the container, measured and recorded in the same operation. It is for oils what a cash register is for money.

It is the easiest thing in the world to close our eyes and ears to new plans and equipment for doing things because the change may require a little investment or alteration. We argue to ourselves that the old way is comfortable; it has served us for, perhaps, many years. We have been able to make a living and perhaps accumulate a surplus profit, so why should we experiment? Trying to justify to ourselves a continuance of out-of-date methods is a great hindrance to progress and greater profits. We must stop the leaks that cut down our profits. The several illustrations herewith show the dangers attendant upon storage of oil in wooden barrels, as well as the waste of both time and oil.

A typical tank holding 120 gal. of oil is 21 in. in width, 50 in. front to back and 29½ in. high, which means a saving in space when compared with any other system or method. Tanks may vary in capacity but are standard in height and depth, the width only being increased to allow larger capacity.

If you will break open one of your empty barrels and carefully examine the interior, you will realize the loss sustained through evaporation, absorption and congelation. You will see sticking to the interior of the barrel, in a half dried condition, large quantities of "foots and fats." This residue was many times its present bulk when originally purchased in liquid form. Now, it presents a total loss.

If you store paint oils in improvised tin, faucet, or molassesgate containers, you are increasing the possibilities of forming "foots and fats" to a greater degree, owing to the imperfect ventilation of such storage containers and partly to the fact that you draw the oil by gravity only.

Advantage of Neighborhood Plant*

A Suggestion for Building Managers for Economizing in Fuel

THAT some of our present day methods of producing and distributing light, heat and power are extremely wasteful, cannot be doubted. Any improvement over present methods which will place the useful energy of the coal in the premises of the consumer, at lower cost, must at once reflect on the earnings of office buildings.

As this class of building requires heat, light and power, the most efficient method of meeting these demands on a fuel saving basis is discussed here.

To simplify this subject, buildings will be classed as to the method followed in utilizing the useful heat in the coal necessary to supply their demands.

Class One buildings operate a modern power plant using efficient generating apparatus. The boilers are of the best types and fitted with stokers of good design.

The operating force comprises men skilled in their respective duties, who observe a good standard of discipline.

Repairs and maintenance in the plant and up in the building, are cared for with the rapidity and thoroughness consistent with good management.

The result is manifest in faultless, uninterrupted and economical service.

Coal is utilized to produce steam, which, of necessity, must be kept at a steady pressure, which tends to even furnace temperatures, of vital necessity for high furnace efficiency and the elimination of smoke.

This steam at high pressure goes to the engine for the production of power, where not more than 10 per cent of its heat value is used and then it is exhausted.

In the non-heating season, some of it goes to heat water or some minor uses; but the most of it escapes to the atmosphere and is lost during a five-month period.

In the heating season, the greater part, if not all, of this exhaust steam which has already supplied the needed power, goes into the heating pipes and is used again during a seven-month period.

We believe this particular method of obtaining power and heat from the steam in one operation makes the Class One building a much greater agency for fuel conservation than is generally realized.

That it has not escaped the notice of some of our leading men in power plant study, we quote Chas. P. Steinmetz:

"It is an economic crime to burn coal for mere heating without first taking out as much high grade energy, mechanical or electrical, as is economically feasible. It is this feature, of using the available high grade energy of the coal before using it for heating, which makes the isolated station successful, though it has every other feature against it."

Class Two buildings are those obtaining power from a central station, and operating boilers to meet demands for steam.

On central station economy we desire again to quote Mr. Steinmetz, who says:

"We get at best 10 to 20 per cent of the chemical energy of the coal as electrical energy; the remaining 80 to 90 per cent we throw away as heat in the condensing water, or, worse still, have to pay for getting rid of it."

There is this fuel waste in the generation of power by central stations, at the same time, fuel is burned in this building for hot water and possibly other purposes

* From a paper presented before a committee of the Building Managers' Association of Chicago by a committee of engineers in charge of office and store building plants consisting of John C. Heavey, C. F. Heal and C. Langs.

in the non-heating season, and the heating season for heating the building.

The heating plant does not require a steady pressure of steam as must be maintained on power plant boilers, but may vary over a wide range of pressure and still supply sufficient heat at the radiators. Nor is the attendant, as a rule, a highly skilled man as he usually has other duties to perform, which require that he fire enough coal at one time to attend these other duties, with the result that at times a furnace temperature of over 2000 deg. F. is attained which soon drops to 500 deg. F. or lower.

This mode of procedure must of necessity produce dense smoke, and a low degree of furnace efficiency, which means waste of coal.

The depreciation of boiler and furnace equipment in a damp basement during the non-heating season is very rapid.

The net result in Class Two buildings is a great waste of energy in the production of the necessary power and a far greater waste in the supply of hot water and heat.

The class of help employed on upkeep and repairs does not compare with Class One buildings and if outside mechanics are called in they have not the interest in their work that a regular employe has who remains in the immediate vicinity.

In the Class Three buildings power is obtained from a central station and heat from a heating company. Here, as in Class Two, we have the central station losses in power generation.

In the plant of the heating company we find some improvement over the small private heating plant due to the employment of engineers and firemen.

Were there engines used in conjunction with the boilers so as first to obtain what power the steam would yield and then use the steam in the heating pipes, a considerable amount of waste would be turned to useful work, but the rule generally is to take out the engines in a plant taken over by the heating company.

To leave them in would be admitting the economy of this method of operating.

In Class Three buildings, as in Class Two, steam is used to generate power without making use of the heating value of steam, and then steam is generated only disregarding the power value in this steam. Two widely separated processes are resorted to with the combined waste of each.

The most practical solution of this question of fuel conservation and one which would mutually benefit the country and the building owners, is along the lines of the following:

Buildings designated as Class One have as a rule more power equipment than is ever at any one time in use, which, in congested commercial districts, leaves many idle boilers, engines, and dynamos which might and should be in operation.

In many of these plants, more load would mean greater efficiency without any addition of equipment or labor.

Where a building or plant of Class One adjoins one or more buildings of the other classes, service should be extended to these other buildings to almost the full capacity of the Class One building, in heat, light and power with the added service of a skilled force of mechanics in the immediate neighborhood to care for maintenance and repairs at a moment's notice.

Then heat could be furnished any day of the year and exhaust steam for hot water, hot rooms and many other purposes would be available at all times. The smoke nuisance would cease to exist, and all parties concerned would realize benefits which they do not now obtain, in increased operating economy and better service.

These benefits can be realized from a central isolated, or call it a neighborhood plant, in any congested commercial district where the amount of steam necessary for heating absorbs more than 50 per cent of steam necessary to produce power.

As most of such districts require steam during the short non-heating season for cooking and various other purposes, it is a grave mistake to shut down this type of plant to purchase the necessary power in summer.

It breaks up a trained, efficient organization, as idle help is a burden; the depreciation of equipment is much more rapid when entirely out of service; the benefits claimed, too often do not materialize; it is a short period at best with uncertain weather conditions.

There is no fuel crisis in the summer, but there often is in the winter and the tremendous savings of a neighborhood plant in the long heating season, after deducting the slight losses of the short non-heating season, makes it the ideal solution of economical power and heat requirements, for congested commercial districts.

A neighborhood plant would be justly entitled to preferential rating in coal supply, materials necessary to maintenance and classification of labor with relation to war service.

Current Events

By J. B. Dillon

ONE good turn deserves another,
Thought the embryo at the power house.
Then he gave the rheostat another twist,
And then—the lights went out.

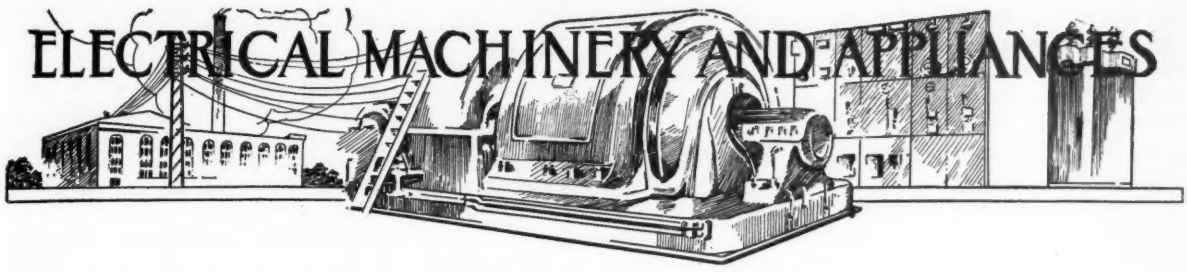
The electrician ran upon the scene,
Oh, how he did let loose and cuss!
But our embryo said: "Mr. Jones,
Shall we try another fuse?"

The Kid's cool demeanor startled Jones;
He forgave him in sheer surprise.
In fact Jones felt real sorry
That he had let go that swear.

Then Jones gave the Kid some good advice,
With which the youth became so engrossed,
He swore he'd never blow a fuse again,
And that he had a dandy boss.

As usual, kind words won the day,
To Jones, the lights never seemed brighter.
So try it as you journey along—
It will make all hearts more comfortable.

Good times for all can only be the product of good work by all.—Forbes Magazine.



A Study of Dynamo Electric Machinery---XI

ALTERNATOR REGULATION AND CONTROL; POLYPHASE MACHINES. BY OTTOMAR H. HENSCHEL

REGULATION of a constant-potential alternating current generator may be defined as the per cent change in voltage (based on full-load voltage and at constant speed and excitation) occurring when under given power factor conditions the load is changed from full load to no load. This may be explained more fully by citing a typical example. Let us assume that under full load the terminal voltage of a machine is 220 v., while as soon as the main switch is opened the voltage rises to 230 v. This is an increase of 10 v. above that at full load. Dividing 10 by 220, we obtain as a quotient 0.045, or 4.5 per cent, the regulation of the machine under the specified conditions.

If, however, the power factor of the receiving circuit is high, regulation is improved (that is, less) and if the capacity of the circuit is in excess of the inductance, the voltage of the machine instead of rising with a release of load will tend to drop; that is, where the full-load voltage as before is 220 v., sufficient capacity in the

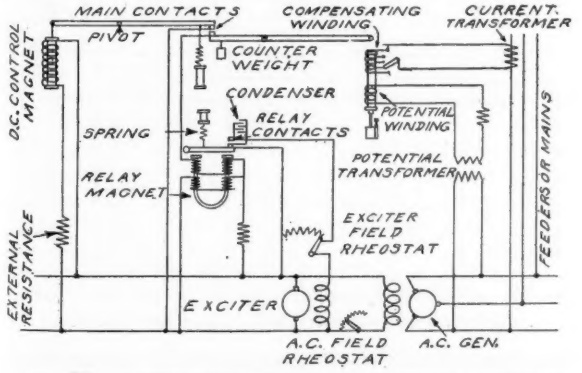


FIG. 76. ELEMENTARY CONNECTIONS, TIRRILL VOLTAGE REGULATOR USED WITH 3-PHASE GENERATOR

receiving circuit may cause a drop in voltage to 210 v. as soon as the main switch is opened. As before, the change in voltage is 10 v. and while the regulation remains 4.5 per cent this assumes a negative value more properly expressed as a negative regulation of 4.5 per cent.

CONTROL OF VOLTAGE

WHERE the current generated is used primarily for the operation of lighting units load changes occur more gradually than in installation in which the load is in whole or partially made up of electric motors frequently carrying variable and abruptly changing loads. Where the former conditions exist regulation changes are gradual and voltage control may satisfactorily be accomplished by manual manipulation of the generator's field rheostat or the shunt field rheostat of the exciter, or both. With but one generator and one exciter installed, both rheostats may be operated without harm; although it is preferable, and especially so where a single exciter is used, to serve two or more generators to use the exciter field rheostat only to maintain proper exciter voltage and the generator rheostat for the control of the bus voltage.

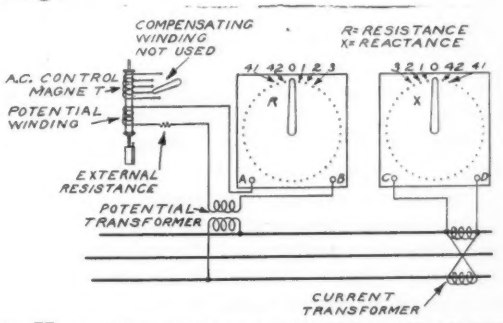


FIG. 77. METHOD OF CONNECTING LINE DROP COMPENSATOR

Few plants are, however, employed for lighting service only and with the large generating units now in use, supplying current to hundreds of motors with their various characteristics and changing loads, it would be a physical impossibility to provide a satisfactory terminal voltage without the use of some form of automatic device.

AUTOMATIC REGULATOR

THERE are two general methods of automatic voltage regulation. In the first, as used in the Thury regulator, the field resistance is automatically adjusted by motors or solenoids controlled by a relay; in the second method, which is that employed in the Tirrill regulator, a resistance is alternately cut into and out of the generator field circuit. The essential parts of the regulator, see Fig. 76, are a direct-current control magnet, an alternating current control magnet and a relay. The first-mentioned, which has a fixed stopped core in the bottom and a movable core in the top, is connected directly across the exciter bus bars; the movable core is attached to a pivoted lever having a flexible contact capable of being pulled downward by helical springs. Opposite this is a second pivoted lever having at one end a con-

tact and counterweight and at the other end a movable core under the influence of an alternating-current control coil, consisting of a potential winding connected to the main generator bus bars through a potential transformer and an adjustable compensating winding connected through a current transformer to the main lighting feeder.

The U-shaped relay magnet is provided with a differential winding, both sections of which, like the direct-current control magnet, are connected across the exciter bus; one of these sections is connected direct while the

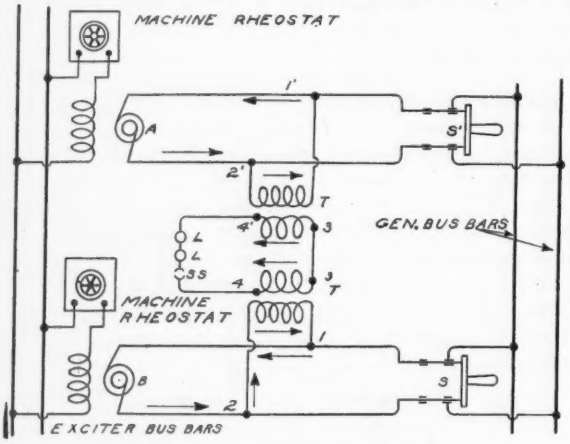


FIG. 78. DIAGRAM OF CONNECTIONS OF SYNCHRONIZING TRANSFORMERS, LAMPS AND SWITCHES AS USED WITH TWO SINGLE-PHASE GENERATORS

other is connected through the main contacts. The armature used with this relay forms a means of short-circuiting the exciter field rheostat through contacts provided for the purpose; condensers connected across these contacts prevent destructive arcing.

Where the system fed has a variable power factor, better results are obtained by eliminating the compensating winding and employing a line drop compensator. This consists of an adjustable resistance and reactance connected as shown in Fig. 77.

When, due to excessive load or otherwise, the main bus voltage is below normal, the weight of the core of the alternating-current control magnet overcomes that of the counterweight and closes the main contacts, causing the relay magnet to act upon its armature and close the relay contacts. This short-circuits the exciter field rheostat, raising the exciter voltage and in turn the generator voltage. As soon as the exciter voltage is increased, the direct-current control magnet exerts a greater pull upon its core, which, being attached to the pivoted lever, raises the upper main contact; and with the bus voltage below normal, the lower contact follows. As the bus voltage, however, approaches its normal value, the main contacts are opened, the relay magnet is caused to draw down its armature, the relay contacts are opened and the exciter resistance is again cut into circuit. Due to the sensitiveness of the magnets, this operation is continued at a high rate of vibration and, as a result, a pulsating exciter voltage of required value is maintained.

Alternator Control

When parallel operation of alternating-current generators is desired, greater precautions must be exercised than in the case of direct-current machines. Due to the fact that such electromotive forces alternate through positive and negative values rapidly many times per second, it is necessary that not only the voltage of the incoming machine be equal to that of the bus bars, but that the number of alternations per second, or frequency, should be of like value and the machines must be "in phase"; that is, all corresponding points on the electromotive force curves of the various machines so connected must coincide.

Phase relations may be determined by means of synchronizing lamps or synchronism indicators; due to their greater degree of accuracy and reliability, the latter are, however, more generally employed.

In Fig. 78 are shown two single-phase machines, A and B, feeding a pair of bus bars through switches S' and S. Connected to the machine leads are two transformers, T' and T, the secondaries of which are connected in series with synchronizing lamps. L' and L, and switch SS. With the machines in synchronism, as they must be when operating in parallel, the direction of current flow from A and B through the primaries of transformers T' and T respectively is indicated by the directions of the arrows. In each case, this flow of pri-

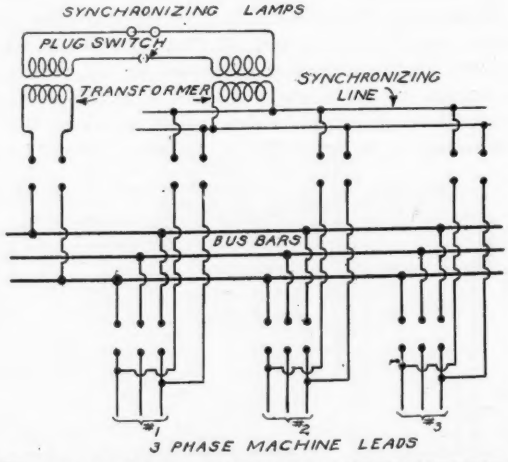


FIG. 79. SYNCHRONIZING EQUIPMENT CONNECTIONS FOR AN INSTALLATION OF THREE 3-PHASE GENERATORS

mary current is from left to right; that in the secondary windings we know from the theory of the transformer is at any instant in a direction opposite to that in the primaries or, in this case, from right to left.

Consequently the electromotive forces induced in the secondary windings of these transformers oppose or neutralize each other and the lamps remain dark. It is, therefore, apparent that with the connections shown the only time to throw machines A and B in parallel is after their respective voltages are of like value and the synchronizing lamps are dark.

If, however, it is desirable to indicate complete synchronism with the lamps up to full candlepower, reverse the secondary of either transformer.

Due to the fixed relation existing between the various phases of polyphase machines it is necessary to syn-

chronize only one of the phases. Synchronizing equipment connections for an installation of three 3-phase machines are shown in Fig. 79.

Whether lamps shall be "light" or "dark" for complete synchronism may be readily determined by means of the following procedure. In the case of a two-machine installation, raise the brushes on one of them, throw in the main switches and note whether the lamps are "light" or "dark." If dark, the machines are to be thrown in parallel with the lamps out; if lighted, complete synchronism is to be recognized by this condition. A similar procedure is easily arranged for machines with stationary armatures by disconnecting the proper leads.

Alternator Ratings

As in the case of direct-current generators, the output of an alternator in amperes is dependent upon the degree of heat generated within the machine; or, in other words, the heating effect determines the current rating of the machine, and the power rating of an alternating-current generator is always understood to be the power it can deliver at unity power factor without an undue rise in temperature; that is, the power rating is the product of its rated voltage and its rated current.

Unlike the direct-current generator, however, except under conditions of unity power factor, the power rating of an alternator should not be expressed in watts, or in kilowatts, but in volt-amperes or kilovolt-amperes. The reason for this is obvious when we consider the case of a typical machine operating at various power factors. Let us assume a 2300-v. alternating-current generator having a current rating of 500 amp. At full load and at a power factor of unity, the power rating is equal to the product of 2300 and 500, or 1,150,000 volt-amperes or 1150 kv.a. which, under the power factor conditions given, may be expressed as 1150 kw. If, however, this machine is made to deliver a like amount of energy, namely 1150 kw., but at a power factor of 0.80, or 80 per cent, the current flow will be in excess of 500 amp.; to be exact, it would be equal to the quotient obtained by dividing 1,150,000 by the product of 2300 and 0.8 or 625 amp. and as a consequence, undue heating would result. It is to guard against such occurrences that alternating-current generators are rated in kilovolt-amperes rather than kilowatts.

Polyphase Machines

Single-phase alternating current is today employed but to a very limited extent for any other than lighting service and as the majority of electric systems with their connected transforming devices and power-consuming apparatus use only polyphase alternating current, it is desirable to pay some attention to the polyphase systems. Although theoretically any number of phases may be employed commercially, only two- and three-phase systems are in use and while upon the introduction of the induction motor, two-phase systems rapidly supplanted the single-phase, these have again been in turn superseded by the three-phase system with its lesser copper requirements. Except for special service, the three-phase is the most widely used.

For the generation of two-phase current two electrically, although not mechanically, distinct armature windings are provided and so placed relatively one to the other that their electromotive forces and currents are displaced by 90 deg. or as is generally termed, are in quadrature. The diagram, Fig. 80, is illustrative of this.

Vector OA represents the electromotive force in phase A while 90 deg. in advance is vector OB representing the electromotive force of phase B. Ordinarily where the currents of the two phases are of equal value and supply circuits of like power factor, vectors Oa and Ob, representing the value of the current in phases A and B respectively, are of equal length and lag behind (or where capacity predominates lead) vectors OA and OB by equal amounts. The degree of lag may be represented by any desired angle, as X, although the actual value of this angle is dependent upon the power factor of the circuits supplied with current.

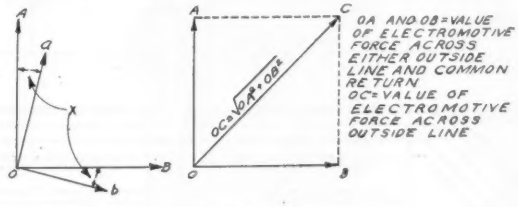


FIG. 80. ELECTROMOTIVE FORCE AND CURRENT RELATIONS OF A 2-PHASE ALTERNATOR

FIG. 81. ELECTROMOTIVE FORCE RELATIONS OF A 2-PHASE 3-WIRE SYSTEM

The armature leads of any two-phase machines of the stationary armature type may be either three or four in number. When but three are utilized, one of the leads is employed as a common return for the other two and the current flow through such a common return line is at any instant equal to the square root of the sum of the squares of the other two instantaneous current values. Similarly the electromotive force across the two outside lines is equal to the square root of the sum of the squares of the instantaneous electromotive force values across the common return lead and the two outside lines.

Questions and Problems for Review

1. Draw a diagram of connections of a Tirrill voltage regulator as used with a 3-phase generator and explain its method of operation.
2. How are lamps connected to indicate complete synchronism at full candlepower? Show this by means of a diagram of connections.
3. Why are alternating current generators rated in kilovolt amperes rather than in kilowatts?
4. Show by vector diagram the electromotive force and current relations of a 2-phase alternator.

President of Baltimore and Ohio Railroad, in a speech before the Baltimore Chamber of Commerce, said that unless railroads were granted means of getting increased revenues in proportion to increased cost of operation when returned to private control, they would revert again to government control. Increase in cost of operation, he said, was about 70 per cent since 1916.

Temperature Indicators for Alternators

THEIR CONSTRUCTION AND APPLICATION. BY S. L. HENDERSON

THE HIGH STANDARD of continuous service which modern power stations aim for and the use of the modern high-capacity generating units make it necessary to pay strict attention to the maintenance and operating conditions of the generating equipment. Cost of repairs on large generators on a percentage basis may be no larger than on smaller units, yet repairs take longer and are harder to make, and furthermore the shut-down of one of these large units is felt more seriously, since each unit is a large percentage of the station output.

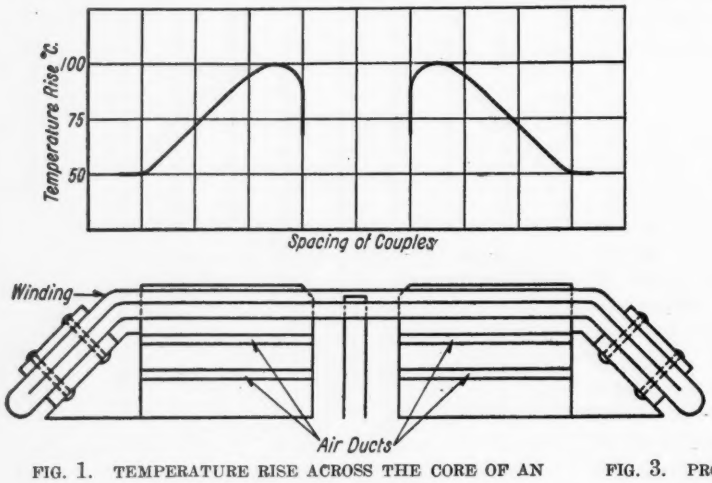


FIG. 1. TEMPERATURE RISE ACROSS THE CORE OF AN AXIALLY VENTILATED MACHINE

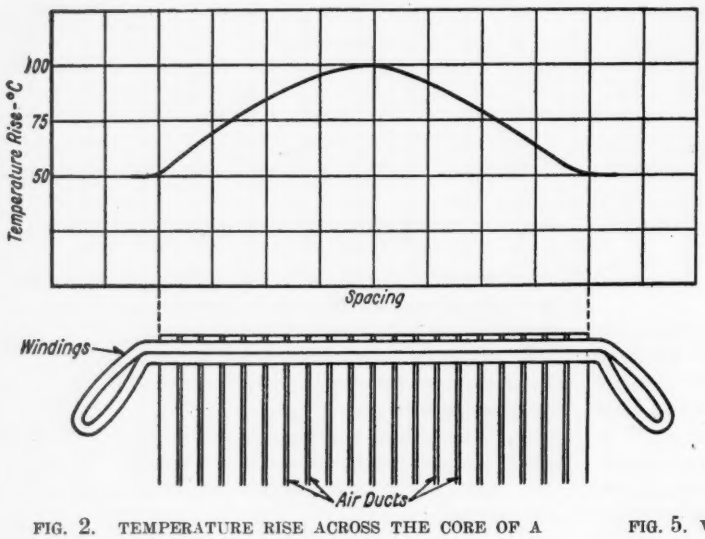


FIG. 2. TEMPERATURE RISE ACROSS THE CORE OF A RADIALLY VENTILATED MACHINE

As an aid in keeping in close touch with the operating conditions of these large generators, temperature detectors have been developed which give a means of determining more closely what the operating temperatures are than is possible with thermometers on the end windings.

Considerable study and research work was necessary in order to know just where these detectors should be located in the generator, in order to read the highest temperature it was possible to measure. The heat distribution in one of the larger generators is a complex problem, but in general the buried portion of the coil is hotter than the ends, because this part of the coil is surrounded by iron which is hotter than the cooling air which blows over the ends. In most types of ventilation, excepting those which admit air at the center of the machine, the buried copper midway between the ends will be the hottest, for the reason that the temperature of the cooling air which reaches the center of the machine is already raised by the heat picked up due to friction, windage, and iron losses. Consequently, the copper temperature is increased a corresponding amount if the

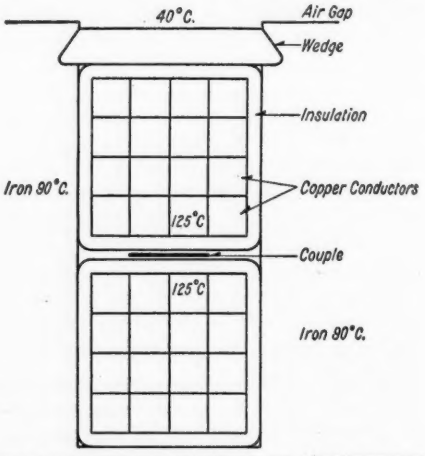


FIG. 3. PROPER LOCATION OF DETECTOR IN ARMATURE SLOT

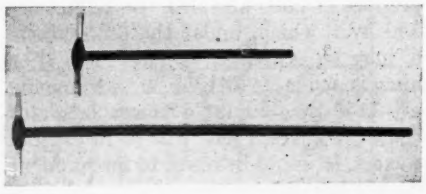


FIG. 4. TWO LENGTHS OF THERMOCOUPLES

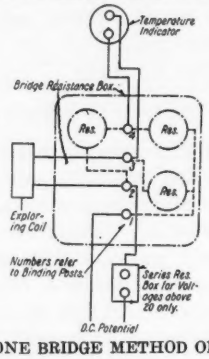


FIG. 5. WHEATSTONE BRIDGE METHOD OF TEMPERATURE MEASUREMENT

coil is to get rid of its heat. Figure 1 illustrates in a general way the temperature gradient in an axially ventilated machine and Fig. 2 that in a radially ventilated machine. It has been found, as the result of a large number of tests, that if one of these detectors is placed in the center of the generator between the top and bottom coils, as shown in Fig. 3, the temperature observed will be the maximum which it is possible to measure safely. Laboratory tests have been made with the detector against the bar copper, but this cannot be recommended for practical testing because, even though placed

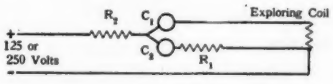


FIG. 6. BALANCED RESISTANCE METHOD OF TEMPERATURE MEASUREMENT

on the neutral coils, it might be possible to have a dangerous voltage to ground due to line disturbances. Variations in design affect the exact location of the hot spot and it must be left to the judgment of the manufacturer, who is constantly obtaining data on temperatures, as to just where the detector should be placed.

Detectors should be rugged and easily placed in the machine without possibility of injury. They should be insulated to stand any temperature with which they are likely to come in contact, to prevent their becoming worthless after a time, due to short-circuits within themselves. Figure 4 is a view of a pair of these detectors.

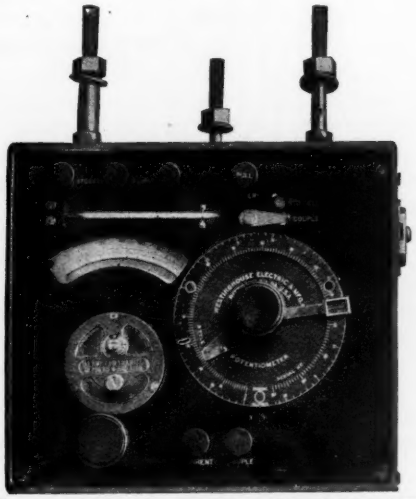


FIG. 7. SWITCHBOARD TYPE OF POTENTIOMETER OR TEMPERATURE INDICATOR

There are two general methods of measuring temperatures by detectors known as the exploring coil method and the thermo-couple method.

Exploring Coils

The simplest exploring coil method is one which employs the Wheatstone bridge arrangement in which the fourth arm of the bridge consists of a resistance coil embedded in the armature winding. This coil is wound on a strip of mica using a large number of turns of small wire. The finished coil is about 5 in. long and 1/16 in. thick and has a resistance of approximately 30 ohms. This resistance must be kept high so that the resistance of the leads will be small in comparison.

The other three resistances completing the bridge are located at the switchboard. The value of these three resistances is such that when the temperature of the exploring coil has reached some predetermined value the bridge is in balance and there is no difference in voltage between points 3 and 4, Fig. 5. At any other temperature there is a difference in voltage between these two points, but within the range of temperatures obtained the error from this cause is slight. A standard type of voltmeter is used with a scale laid off in degrees. Any constant source of direct current is sufficient and if this is above 20 v. a series resistance is furnished. The value of the resistance is generally such that when the exploring coil is at 90 deg. C. the instrument is at zero deflection and this point is marked 90 deg. C. Care must be taken that the impressed voltage is held at the value for which the series resistance was furnished, otherwise the indications will be in error on readings other than 90 deg. C.

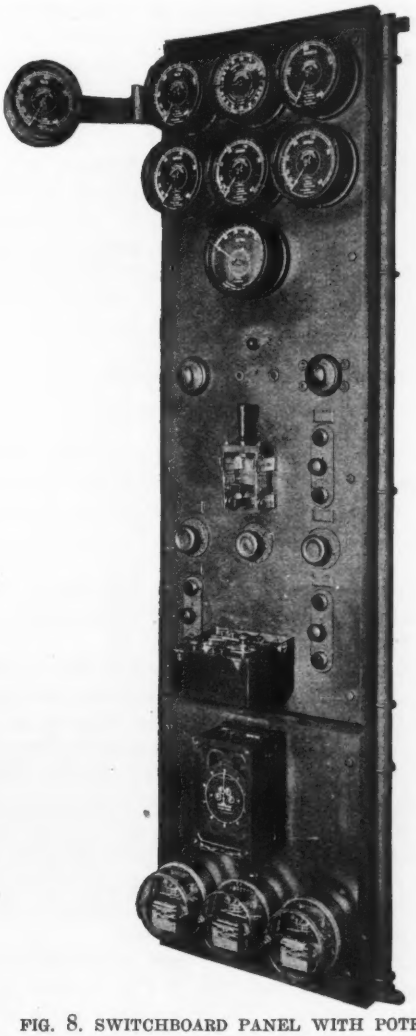


FIG. 8. SWITCHBOARD PANEL WITH POTENTIOMETER

The exploring coils are expensive to make, not only

on account of the number of turns of small wire, but also on account of the amount of testing and adjustment required to secure the proper resistance. They are also subject to short-circuits and open circuits when they are placed in the machine.

The complete equipment necessary for use with exploring coils will consist of:—

1—The exploring coils, usually six per generator.

2—A terminal board on the generator frame, usually located near the main leads for convenience, and to which the individual coils are connected.

3—A multi-conductor cable used for connecting the individual coils to the instrument. (It is customary to connect one side of all the coils to a common lead

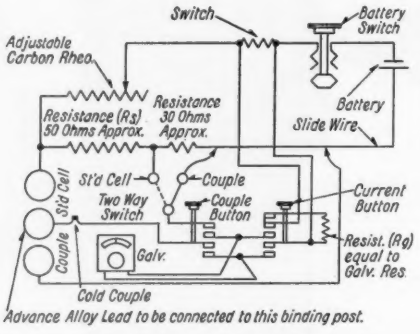


FIG. 9. DIAGRAM OF CONNECTIONS

so that if six coils were used a seven-conductor cable would be necessary. One side of the circuit is preferably grounded for protection of the operator and to eliminate all possibility of any static affecting the accuracy of the meter.)

4—A dial switch located near the instrument and used to connect the coil on which the measurement is desired to the meter.

5—A suitable meter, usually arranged for switchboard mounting, together with the resistance box containing the three permanent resistances referred to in the preceding paragraphs, and when the source of supply exceeds 20 v. an additional resistance of suitable value to cut down the voltage from the source of supply to less than the predetermined figure of 20 v. maximum.

In using this equipment, it is not good practice to leave any one exploring coil permanently connected in the circuit since the effect is to heat the exploring coil, with a possibility of burning it out in time.

Another exploring coil method used as standard by another manufacturer is outlined in Fig. 6, and is a balanced resistance method. The detector is a coil wound with copper wire, which has a resistance of approximately 10 ohms and is approximately 10 in. long. Three leads are run from each detector to the switchboard. Resistance R^1 and the resistance of the temperature coil are alike at some given temperature, say 80 deg. C. Resistance R^1 has a zero coefficient (i.e. its resistance does not vary for changes in temperature). The temperature coil has a positive coefficient (its resistance increases with temperature). The two coils in the instrument C_1 and C_2 are wound differentially. An external source of current supply is required and is usually 125 or 250 v. Adjustable resistance R_2 is used to modify the current when the voltage varies from normal.

When the resistance of the temperature coil and resistance R_1 are alike, the current is equal in coils C_1 and C_2 and the instrument is not deflected. As the temperature of the machine increases, the resistance of the temperature coil increases, and the current of this arm in series with coil C_1 becomes less than the current through C_2, and the coil is deflected.

The principal of operation is quite different for these two exploring coil methods, and while they both make use of a resistance coil, the instrument of one cannot be used with the temperature detectors of the other.

THERMOCOUPLES

THE THERMOCOUPLE method depends on the fact that a difference of electrical potential exists at every junction between dissimilar metals. In a closed circuit made up of two dissimilar metals there must obviously be two junctions. If these two junctions are at the same temperature the two e.m.f.'s will be equal and opposite and no current will flow in the circuit. If, however, one junction is maintained at a different temperature from the other there will be a difference in the e.m.f. that throughout the range of temperature en-

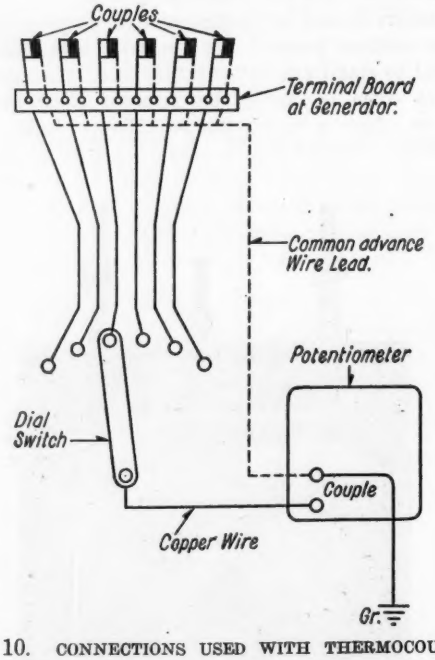


FIG. 10. CONNECTIONS USED WITH THERMOCOUPLES

countered in electrical machinery will be proportional to the temperature difference. The method, therefore, in its simplest form requires a hot and a cold couple and a device for measuring the difference in electromotive force between the two couples.

The couples are made by welding copper and advance (nickel-copper) alloy ribbons together. These ribbons are ordinarily 0.005 in. thick, 0.25 in. wide and of any desired length. The couple is insulated with mica and micarta paper to withstand a temperature of at least 150 deg. C. and substantial leads are brought out to the edge of the slot, and from the edge to the terminal board. The cold couple is located at the end of the advance wire leads and inside the measuring instrument.

With a difference of 1 deg. C. between the temperatures of the hot and the cold couples, the difference in e.m.f. is approximately 40 micro-volts. This small voltage would force through the circuit only a very small current so that the measuring instrument must be somewhat different from the ordinary indicating meter type if a rugged, reliable device is to be obtained.

In Figs. 7 and 8 are shown two views of the instrument used, one as it is arranged for switchboard mounting and the other showing it mounted on the generator panel. It will be noted that it is arranged for mounting in a horizontal plane.

Mounted in this instrument case are the following parts:—

1—The cold couple.

2—In contact with the cold couple a small bulb type mercury thermometer by which the temperature of the cold couple is observed.

3—A dry cell supplying current through a resistance wire on which are two sliding contacts.

4—A graduated scale and two pointers which move with the contacts and which indicate the position of the two contacts.

5—A deflection needle of the galvano-meter type.

6—A rheostat used for adjusting the current in the battery circuit to the proper value. The scheme of connections is shown in Fig. 9.

When the couple button is closed the galvanometer needle will indicate a deflection unless the e.m.f. between the contacts is equal to the couple e.m.f. The deflection of the galvanometer needle will be in one or the other direction depending on whether the thermocouple e.m.f. is higher or lower. By changing the distance between contacts, using the galvanometer as a guide, the position in which the slide e.m.f. balances the thermocouple e.m.f. is easily located. In practice, the lower pointer is set at the position on the scale corresponding to the temperature of the cold couple and the upper pointer is moved until a balance is obtained as described. The actual temperature of the hot couple can then be read directly on the scale.

The temperature measured by the potentiometer is the difference in temperature between the hot couple and the cold couple. The indication on the slide wire scale, however, is the total temperature of the hot coil, since the setting of the lower pointer on the scale at the temperature of the cold couple mechanically adds this temperature to the potentiometer or indicator measurement.

A general scheme of connection is shown in Fig. 9. The entire equipment required for use will consist of the following:—

1—Thermocouples located in the machine, usually six to a machine.

2—A terminal board mounted on the machine near the main terminals for convenience.

3—A multi-conductor cable is used to connect the individual couples to the instrument. (In ordinary practice, individual copper wire leads are used to connect each individual couple to the instrument and a common advance alloy lead connects all the couples to the instrument. This side of the circuit is usually grounded in order that no voltage may be carried to the switchboard by failure of the armature coil insulation to the couple which would allow generator potential on the circuit. Also in order that any static disturbance may not affect the accuracy of the instrument.)

4—A dial switch, usually located on the switchboard near the indicator, used for switching each individual couple on which measurement is desired to the indicator.

5—The temperature indicator or potentiometer.

Deterioration of the couple is likely to take place if it is left in the circuit continuously and the couple button on the instrument is used for closing the circuit only when a reading is desired.

The dial switches from a number of machines may be interconnected and this makes it possible to read the temperatures from a number of machines at one point and with one instrument. This arrangement is shown in Fig. 11.

Either the exploring coil or thermocouple method, when properly installed, will give a satisfactory means of following the temperature conditions in large generators. The thermocouple method should give nearer the maximum measurable temperature, as it indicates the temperature at a spot while the exploring coil gives

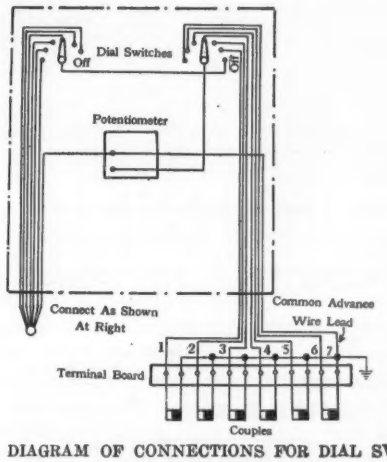


FIG. 11. DIAGRAM OF CONNECTIONS FOR DIAL SWITCHES

the average temperature over its length. There is an advantage also in the thermocouple method in that it is self-contained and requires no external source of voltage and is fully as easy to operate as either of the exploring coil devices. The thermocouple device is a zero reading method; consequently the resistance of the leads does not affect the calibration. The fact that it does not employ an indicating instrument cannot be considered a handicap, as usually it is desired to read all the detectors, and this requires a certain amount of manipulation with either method.—THE ELECTRIC JOURNAL.

WALL STREET JOURNAL announces that the labor situation in England is considerably improved by cessation of unemployment doles to civilians, about 100,000 of whom are now seeking employment. It also states that the government will continue aid to demobilized service men and women until March, 1920, 4,500,000 of whom, including munitions workers, have been absorbed into peace industries.

Britain's Floating Electric Power Station

Oil-Fired Plant Carried on Large Steel Barge

IT IS a truism that the war is a contest of mechanisms, and there is scarcely a branch of engineering that has not been called upon to give its assistance in the formation of the complicated and successful fighting machine. Among the many problems calling for solution has been the question of electric power supply to meet very variable conditions overseas, and we are now able to publish particulars of a plant giving the necessary mobility and convenience which was designed under the direction and for the service of the Directorate of Inland Waterways and Docks, War Office. It takes the form of a floating electric power station, and the nature of the duty calls for such a wide range of supply that the equipment has many interesting features. Direct-current supply can be given between 110 and 575 v., and alternating current from 220 to 7600 v.

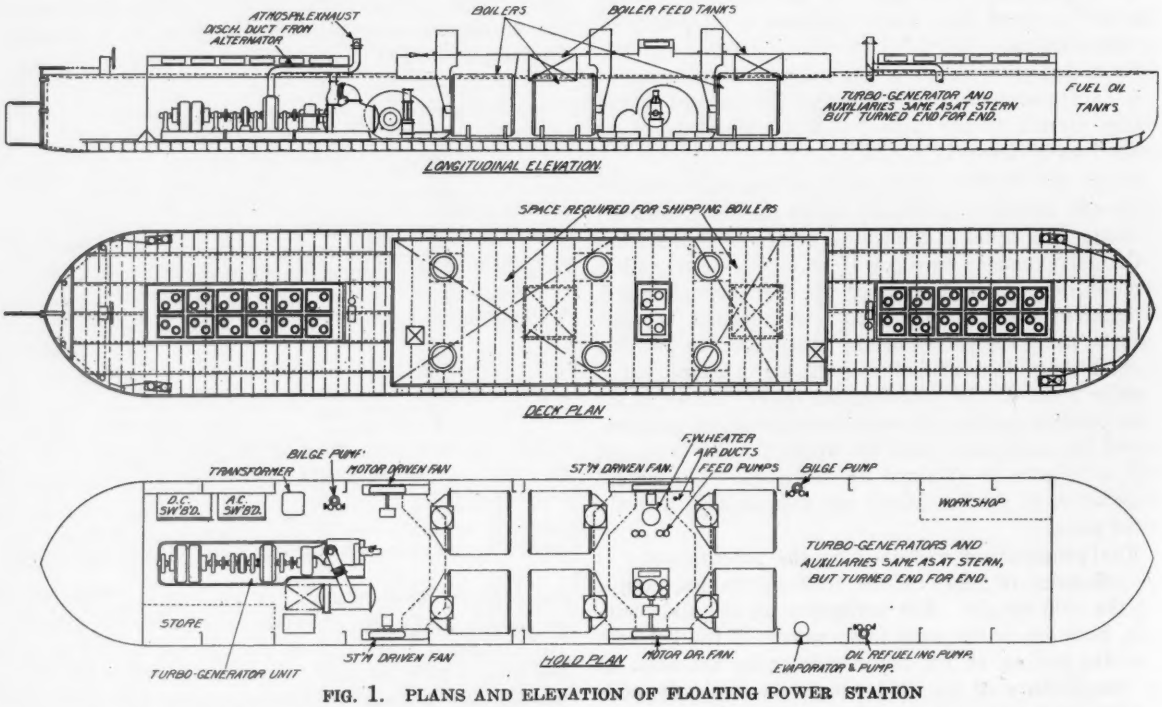


FIG. 1. PLANS AND ELEVATION OF FLOATING POWER STATION

The plant is installed on a large steel barge, and the accommodation consists of two dynamo rooms, placed fore and aft, and a boiler-room amidships. As the boilers are oil-fired, it has been possible to make the installation exceedingly compact, and to reduce to a minimum the personnel required for operation. The nominal capacity is 1000 kw., but owing to the elasticity obtainable with liquid fuel and the generous design of the machines, a considerably larger output may be obtained at short notice for peak loads.

The steam-generating equipment consists of six single-ended single-furnace boilers of marine type, of 800 sq. ft. total heating surface. They have each an equivalent evaporation of 5500 lb. per hour, the working pressure being 200 lb. per square inch. Under these conditions and with feed water at a temperature of 150 deg. F. the rate of evaporation is about 13 lb. of water per pound of oil having a higher calorific value of 19,000 B.t.u. per pound. The oil-burning system is of the low-pressure type—that is, for a working oil pressure of 60 to 70 lb. per square inch. There is one burner per boiler and these are fed from the oil pumps through a ring main system, so that there are two fuel routes to each burner. The oil-fuel pumps and hot and cold filters are in duplicate, and the working pressure is adjustable by means of a spring-loaded valve which bypasses to the pump suction. There are two oil tanks, each having a capacity of about 20 tons, and these are replenished by a re-fueling pump, thus making the station independent of the type of craft furnishing the supply.

Air-supply to the furnaces is maintained by steam-driven, or alternatively, motor-driven fans, the motors being 440-v. squirrel-cage machines. The steam fans are used for light load conditions or when there is no alternating-current load being supplied. The dynamo rooms and boiler room are so arranged that the air is drawn through the former, thus helping to keep them cool. This is particularly necessary in the aft dynamo room, as two of the boilers face this room in order to economize space. The make-up feed water is provided by a marine type evaporator operating with exhaust steam, which discharges to the hot well. On the way to the boilers the water passes through a filter placed on the suction side of the feed pumps, which are of the vertical direct-acting type.

There are two generating sets in each station, each set consisting of turbine, speed-reduction gear, alternator, exciter, and direct-current generator, these five

units being mounted on a sectional cast-iron bed-plate and connected by two flexible couplings.

The turbines are of the impulse-reaction type of 500 kw., economical rating taking saturated steam at 200 lb. per square inch above atmosphere, and exhausting at an absolute pressure of 1½ lb. per square inch. The speed is 5000 r.p.m., and is reduced to 750 r.p.m. by the reduction gear. The governing gear includes a trip device to operate the emergency valve in the event of failure of the lubricating oil pressure. The greater part of the reaction portion of each turbine is fitted with what is usually termed "end tightening" blading, that is, having axial clearance, the last few rows having the usual tip clearance. The end thrust is taken up entirely by a Mitchell thrust block which is arranged so that the axial clearance of the fixed and moving blades can be increased when starting up. Exhaust steam is taken into a surface condenser of 785 sq. ft. cooling surface, served by a steam-driven centrifugal pump for circulating water and a marine type air pump which discharges to the hot-well.

All auxiliaries, except motor-driven fans, are steam-driven, and the exhaust steam is collected and utilized for feed water and oil-heating. The arrangement consists of an exhaust main collecting from the engine driving the circulating pumps, fans, air pumps, etc., and distributing to the tubular feed-water heater and evaporator. A branch to the oil tanks also serves the heating coils there to reduce the viscosity of the oil when necessary. These arrangements ensure the maximum use being made of the steam supplied to the auxiliaries, so helping to maintain the overall efficiency of the plant.

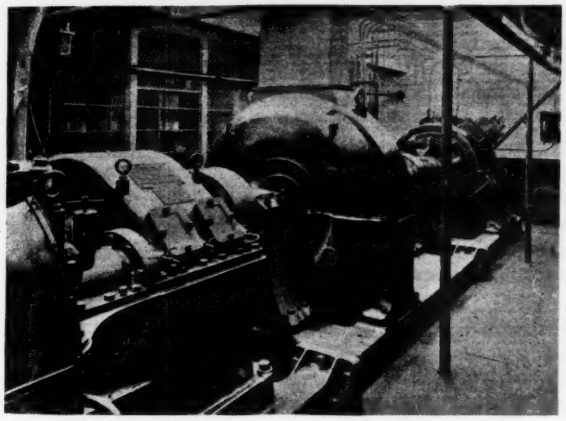


FIG. 2. TURBO-GENERATOR IN THE AFT DYNAMO ROOM

Each alternator has a continuous rating of 625 kv.a., the normal voltage being 440. They are eight-pole, forced ventilated machines, with rotor fans drawing the air in axially and discharging through a vertical duct above deck level. The field system is of the salient-pole type, poles and rotor center being in one piece and of cast steel. The field windings are of strip on edge, and heavy damping coils are fitted to the laminated pole tips. The exciters are low voltage machines, 38 v., and supply also the field current of the direct-current generators.

The direct-current generator consists virtually of two machines with armatures back to back, capable of a combined output of 500 amp. at 220 v. to 575 v., i. e., 110 to 287 v. per armature; the intention being that either a three-wire system or a 500-v. traction circuit may be supplied. With an alteration to the connections of the field coils, the machines may be run self-exciting instead of from the exciter. Over-compounding up to 15 per cent at full load can be obtained, and a diverter switch on the generator frame enables this to be adjusted in four steps from plain shunt. All these machines can safely deal with an overload of 50 per cent for 2 hr., and parallel running is also arranged for between the two engine rooms on both the alternating current and direct-current supplies.

To supply high-tension systems there is a 500-kv.a. three-phase transformer provided for each alternator. These transformers are oil-cooled with radiating tubes and fitted with an expansion chamber. The ratio is 440/1936 per limb, but the windings can be connected in various ways, which, combined with alternator regulation of 400 to 600 v. by rheostats, enable practically any transformer terminal voltage between 1760 and 7600 to be obtained. The secondary windings are in two separate sections and the various arrangements possible give six different ratios, with all of which the transformers can be operated at full load. Two further ratios can be obtained, making eight in all, by star-connecting the primary windings; these, however, do not allow the transformer to be operated at full load except for short periods.

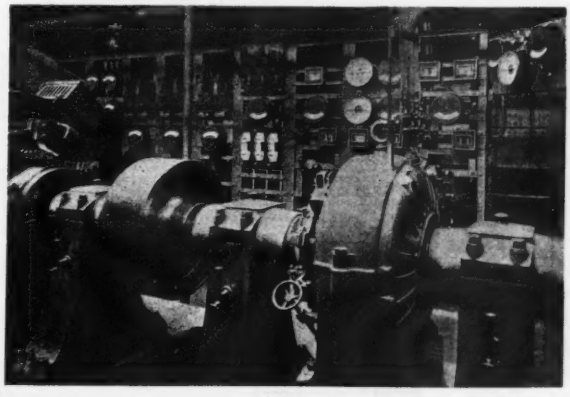


FIG. 3. THE SWITCHBOARD

The switchboards are of a skeleton design, with the usual control gear and protective features. Provision is made for supplying direct-current lighting, power and traction, and as already mentioned, this can be done within a range of 110 to 575, a changeover switch on the generator panel connecting to the alternative feeder circuits. The control of alternating current is done by three panels with oil switches, etc., one of these panels giving a supply to the transformer which is placed adjacent to the switchboard. There is no high tension switchgear on board. Cab-tyre sheathed cable has been used extensively for machine and other short leads, and paper-insulated lead-covered cable for interconnections between the two dynamo rooms.

In spite of the limited space, room has been found for a well-appointed workshop equipped with lathe and drilling machine, etc., the tools being driven from a line shaft by a 3-hp. squirrel-cage motor. There are also store room and office, with a ship telephone installation between the dynamo rooms.—Engineering.

Power Plant Troubles

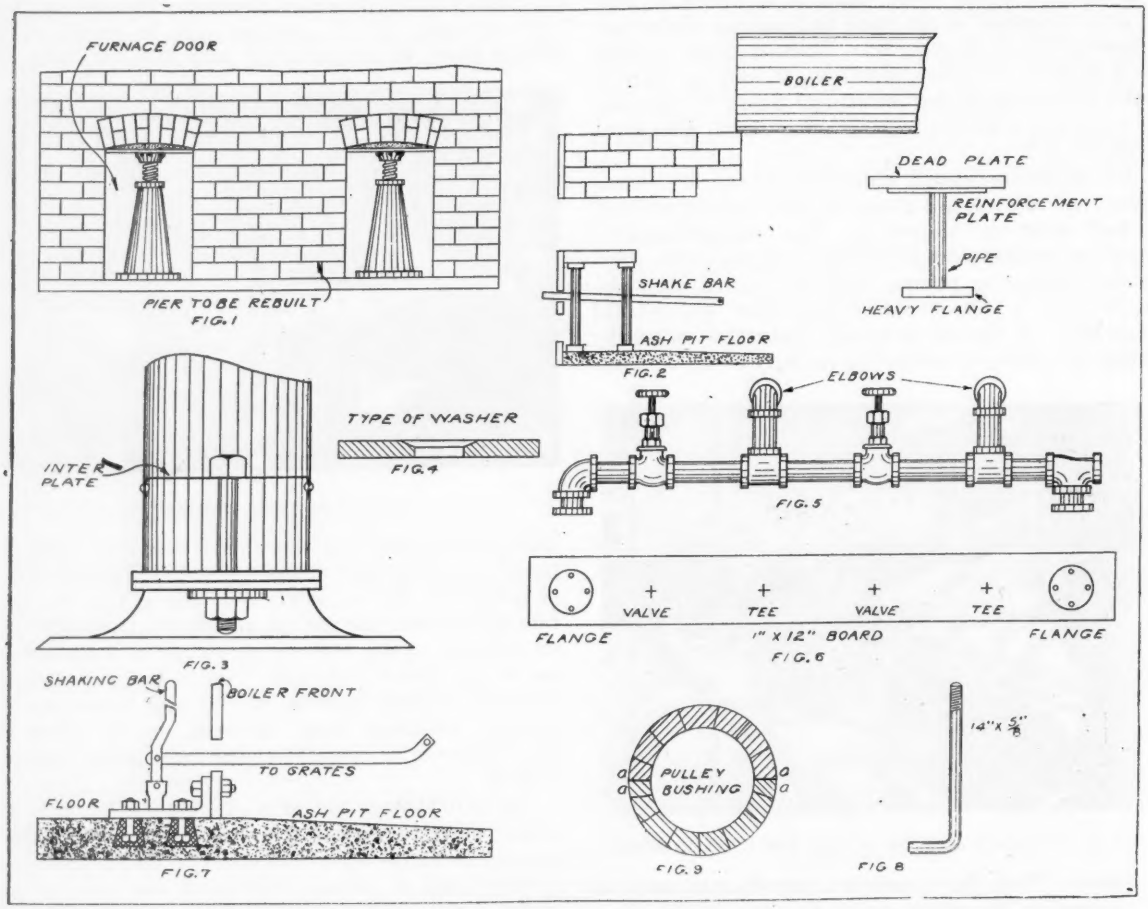
How to Save Time, Money and Effort on a Number of Jobs Around the Power Plant. By H. A. Jahnke

THERE ARE many instances where an engineer is able to save much expense in the up-keep of the plant under his charge by making repairs himself wherever possible, instead of calling outside help to make little repairs, such as replacing a fuse, burned out fire brick in the furnace, repairs on pipes etc.

I have in mind a case where the front pier under the brick lining in a boiler furnace was in bad condition from the firing tools striking it, and there was danger of the whole front lining coming down into the furnace. As there were no iron door linings in this furnace, brick arches were built over the door opening as shown in Fig. 1. The pier under the lining was in bad condition, only the part above being in good condition. The engineer decided to re-build the pier without tearing out the whole front lining and it was done in the following way. Frames were built in the radius of the fire door arches. These were placed under the arches and screw jacks placed under the frames as shown. The jacks were drawn up quite tight under the frames so the lining did not have much chance to move away from the boiler, or to settle. Then the old pier was removed and the new pier built. The last brick coming next to the old lining was wedged in very tight. When the jacks and frames were removed, the old lining did not settle away from the boiler ¼ in. In making the repair in this way, the engineer saved quite an expense to his employer, while the pier and old lining did the work for two years.

Supporting Dead Plate in Center

In another instance, the common grates in the furnace of a return tubular boiler were replaced by shaking grates. This made it necessary to remove the center pier supporting the front dead plate from ash pit floor to make room for the shaker bars, as shown in Fig. 2. As it was impossible to rebuild the pier in this case, 2-in. pipes were placed under the dead plate with flanges next to the ash pit floor, and re-enforcement bars between the plate and pipes. The pipes were then turned out of the flanges sufficiently to place a strain between the pipes and re-enforcement bars. This did the work as well as a brick pier.



TIME- AND MONEY-SAVING METHODS

Water Heater Repairs

A bolt holding the bottom head and intertube head would leak continuously regardless of what packing was placed between the washer and bottom head as shown in Fig. 3. The packing had to be renewed quite often. To get out of the difficulty, a washer was made

of the type shown in Fig. 4; the part of washer which comes next to head and bolt was concaved. A gasket was then made out of round tubular gasket of a size larger than the concave in the washer. Then the washer was drawn up tight with the bolt nut. This compressed the gasket tightly against the heater head. By using a washer of this type, the packing had no way of working out as is the case where a flat washer is used. There was no further trouble after this.

Kink in Pipe Fitting

At one time I had a job of fitting up a piece of pipe work as shown in Fig. 5. All flanges, valves, tees and ells on this particular job had to be made up the same as the old parts were. As the heater was located some distance from the work bench, to save time and labor I hit upon the idea of making the job in the following way: A piece of board was obtained 1 in. thick by 12 in. wide. The pipe job was laid out on this board, the flanges and bolt holes marked and the center of each tee, valve and elbow, as shown in Fig. 6. The job was made and fitted according to this plan. After all joints were made and taken to the job everything fitted nicely. The trouble in this case was that all the old flanges, tees, valves and other fittings had to be used again renewing all the nipples. Some of the nipples were rusted in so badly that it was necessary to saw them off next to the joint and cut the threaded part out of the fitting.

Placing Anchor Bolts

At one time while installing a hand operated stoker into the furnace of a return tubular boiler, it was necessary to place the part which holds the shaker bar, and is bolted to the boiler front and boiler room floor as shown in Fig. 7. The anchor bolts which came with the stoker were of the type shown in Fig. 8, being 14 in. long by ⅝ in. in diameter. I did not care to go to the trouble of cutting a hole as deep as 14 in. in the concrete floor, which would have taken much lead or babbit to fill the holes for anchoring the bolts, so decided to use ⅝ by 5 in. long machine bolts as shown in Fig. 7. This did the work just as well as the 14 in. anchor bolts that I was supposed to use, as the stoker has been in use about 4 mo. now and there is no sign of the bolts coming loose. In doing the job this way, much expense was saved in cutting holes, and material for anchoring the longer bolts.

Wood Pulley Repair

Not long ago, a wood pulley driving a secondary line shaft from the main line shaft started to slip badly and before the engine was shut down, the wood bushing in the pulley was well worn out and burned. It was impossible to draw the bushing up by the pulley bolts so the bushing would grip the shaft again. There was no other bushing of this size in stock and it would have taken some time to obtain one from a dealer. It was necessary to get things moving again as soon as possible, so I was up against it when I hit up on the idea: Why not make the bore of the bushing smaller by sawing off a little on each side, as shown in Fig. 9 at aa, making it possible for the bushing to grip the shaft again, when drawing up on the pulley bolts? After this was done, coarse sandpaper was placed around the shaft. The bushing over this. This did the work without getting a new bushing and things were moving again within half an hour.

Electrical Machinery Demanded Abroad

Fuel Shortage Forces Europe to Use "White Coal"

THE great increase in the price of coal throughout the world has made fuel economy a pressing problem. Reports reaching the National Foreign Trade Council denote a tremendous and continued opportunity for the American electrical manufacturing industry in supplying the needs of these countries, which are now forced to develop their electrical power to the utmost.

Large railroad electrification projects are soon to be carried out in Italy and South Africa. In the former country 800,000,000 lire will be spent for electrification of 6000 kilometers of railroads. Portugal will probably follow in Italy's footsteps. Many of the South American countries are studying this problem, and Bolivia has just declared as public domain the watersheds of the rivers having sufficient power for that purpose. Throughout Chile, many power plants are being built.

In France, a bill recently passed both Houses and has become law for the canalization of the Rhone from Lake Geneva to the Mediterranean. The swiftness of the current of this river will be modified by means of a series of locks and dams, the latter being utilized to generate electric energy and for irrigating purposes. Nineteen large generating stations are to be provided which will furnish electric energy rendering from 12,000 to over 70,000 hp. per station. It is estimated that the river is capable of generating energy equivalent to 760,000 hp., or 4,848,000 kw.-hr. annually, which is equal to a saving of nearly 500,000,000 tons of coal. Two hundred thousand kw. of the energy generated is reserved for the use of consumers in Paris at the price of 2 cents per kw. (locally generated energy now costs 10 cents). The remainder of 560,000 hp. will be utilized by metallurgical, electro-chemical and other industries in the Rhone valley, for electric traction on the Rhone, for the electrification of a portion of the Paris, Lyons and Mediterranean Railway, pumping irrigation water, etc. The cost is estimated at 2,000,500,000 francs.

In the good old days before the present high cost of everything, it was not an uncommon sight to see a wagon pass down the street, advertising something or other by throwing samples to the eager crowds of children which followed. If the samples happened to be apples, there were few that were not smitten with the desire to secure an apple. Some naturally got more than others.

Ten years have passed.

The same crowd is now following a different vehicle, the "opportunity wagon," but not the same large proportion of it is eager enough to get out into the street; some stick to the sidewalk in the hope that the "Opportunity Girl" will happen to throw something in that direction. The front ranks of the crowd, of course, get most of the apples.

Get into the crowd, and up in front!

The Hvid Engine*

And Its Relation to the Fuel Problem.

By E. B. Blakely

A COMPARISON of the Hvid engine of the farm type with a conventional gasoline engine of the same type discloses many factors which show the superiority of the former for this class of work. The Hvid engine has neither electrical devices nor carburetor or mixer. It starts readily on any liquid fuel, even in the coldest weather. On the other hand, the conventional gasoline farm-type engine has electric ignition, which is frequently a source of trouble. It has a carburetor or mixer to be adjusted according to atmospheric conditions and quality of fuel, and finally the gasoline engine is hard to start in cold weather.

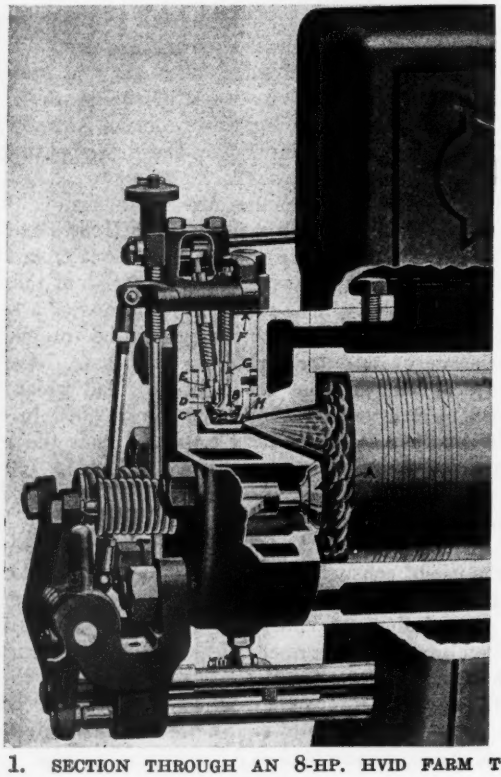


FIG. 1. SECTION THROUGH AN 8-HP. HVID FARM TYPE ENGINE

Briefly enumerated, the chief advantages of the Hvid engine are:

(a) Mechanical simplicity
(b) Low fuel consumption at all loads
(c) Ability to start and run on any oil which will flow
(d) Low water-jacket losses
(e) No lubricating difficulties
(f) Constant compression
(g) Remarkable torque characteristics
(h) Absence of all electrical devices, hot bulbs and torches for ignition purposes
(i) Absence of all carbureting mechanism
(j) No carbon troubles.

* From a paper read before the Annual Meeting of the A. S. M. E., Dec. 2-5, 1919.

The Hvid engine is of conventional four-cycle type, embodying the usual inlet and exhaust valves, timed to open and close as in any four-cycle engine. The compression pressure is carried to between 425 and 475 lb. per square inch, which heats the compressed air to between 900 and 1000 deg. F. In the cylinder head there is a fuel-admission valve terminating in a small steel cup by means of which a preliminary explosion is made to force the fuel into the combustion space. Referring to Fig. 1, the Hvid cycle is as follows:

During the suction stroke, pure air is admitted to the cylinder through intake valve *A*. Fuel valve *B* is opened in synchronism with intake valve *A* and some fuel flows into cup *C* out of hole *D*, which is uncovered by the opening of valve *B* (the fuel enters cup *C* partly by gravity and partly by inhalation). The amount of fuel admitted is controlled by metering pin *E*, which in turn is controlled by the governor. At the same time that the fuel is being inhaled into the cup, a small amount of fresh air is also drawn through an auxiliary air hole *F*, down past a fluted guide *G* into cup *C*. At the end of the suction stroke, fuel valve *B* and air-intake valve *A* close, valve *B* sealing fuel-admission hole *D*.

During compression stroke all valves are closed and the air admitted to the cylinder on the suction stroke is compressed to about 420 lb. per square inch, which raises its temperature to between 900 and 1000 deg. F. In other words, there is now a mass of highly heated air under high pressure in the combustion chamber and this rushes into cup *C* through small holes *H* near its bottom until the pressure in the cup is practically equal to the pressure in the combustion chamber. The conditions in the cup are now most favorable to "cracking" the oil, and as the oil cracks the lighter and more volatile components are detonated by the high temperature and the resultant high pressure within the cup forces the rest of the oil out into the air in the cylinder. The amount of fuel consumed in the cup per cycle is infinitesimal because there is only a small amount of air present in the cup to support combustion.

As the fuel in an atomized and vaporous state comes into contact with the heated air in the combustion space, very rapid combustion takes place and the pressure arising from it drives the piston.

As in any four-cycle engine, the exhaust valve opens and the products of combustion are forced out by the piston.

Indicator Cards

Figure 2 shows a series of indicator cards taken from the 8-hp. Hvid engine of Fig. 1, as well as one from a 20-hp. engine of the same type.

Card *A* is a no-load, stop-spring card which shows a slight vacuum during practically the entire suction stroke and figures approximately 375 ft. per second through the inlet orifice; at the same time it shows good volumetric efficiency. This vacuum is maintained intentionally for the reason that there is left in the injector cup, after the expansion and exhaust strokes, a slight

residual pressure which interferes with the regular delivery of fuel by gravity. Dropping the suction pressure slightly below atmospheric removes this cup pressure, gives a slight pull on the incoming fuel and makes for close governing.

Card *B* is one taken from the inside of the injector cup with the main air-intake orifice not choked and shows a residual pressure in the cup even during the suction stroke of the engine. Card *C* is a full-load card and card *D* is a 25 per cent overload card.

Card *E* is a full-load card from an 8½ by 10-in. 20-hp. Hvid engine in which the ignition point is much more clearly defined than in the cards taken from the 8-hp. engine. There is no doubt that ignition takes place at relatively the same point on the smaller engines, but the speed of the smaller engines is so much higher that the ordinary indicator fails to show it.

It is interesting to note the waves in the expansion line of these cards. These are typical of all cards taken from Hvid engines and are caused by the introduction of fuel oil into the combustion chamber in waves. At

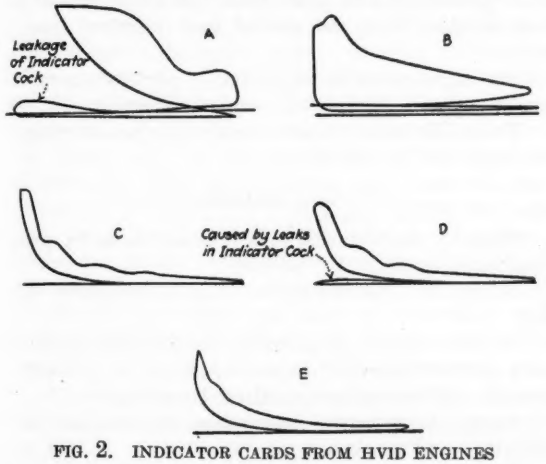


FIG. 2. INDICATOR CARDS FROM HVID ENGINES

the moment when the preliminary combustion takes place in the cup, we have in the cup a pressure of approximately 800 lb., while in the combustion chamber there is a compression pressure of only 425 lb. Some fuel is consequently sprayed out of the cup into the combustion chamber by the attempt at pressure equalization. When the fuel comes in contact with the highly heated air in the combustion chamber, the pressure rises in the combustion chamber and falls in the cup until equalized; then no more fuel can get out of the cup until the piston moves forward and the pressure in the cylinder drops below that in the cup, when some more fuel is ejected from the cup. This is repeated until there is no more fuel left in the cup.

Fuel Consumption

Fuel consumption of small Hvid-type engines is good, being in general on a par with Diesel engines of large size. If Diesel engines could be economically constructed in units as small as Hvid engines can, it is doubtful whether they would compare at all unfavorably in thermal efficiency with the small Hvid units on account of the mechanical inefficiency of the air compressors necessary to inject the fuel. In the comparative fuel-consumption curves shown in Fig. 3 the fuel economy of the Hvid engines as compared with two other types of the same size stands out very plainly, particularly at the lower fractional loads. The engine used in each case was a 5¾ by 9-in., running 450 r.p.m. and rated at 8 hp.

The entropy diagram, shown in Fig. 4, was plotted from a pressure-volume indicator card taken from a 5¾ by 9-in. single-cylinder Hvid-type engine running at 450 r.p.m. and using kerosene as fuel. This diagram is

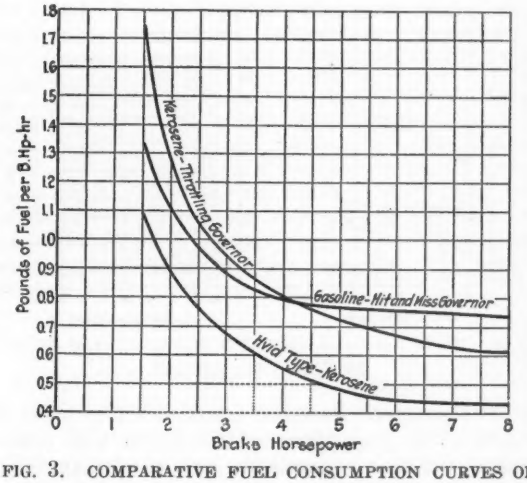


FIG. 3. COMPARATIVE FUEL CONSUMPTION CURVES OF ENGINES OPERATING ON DIFFERENT PRINCIPLE

submitted because it shows the general temperature characteristics, which are quite different from those in an explosive gasoline engine. It is interesting to note the low maximum temperature, 2300 deg. F. abs., as compared with the maximum temperatures for gasoline engines, which frequently run as high as 3000 to 3500 deg. F. abs., and also the sustained temperature in the Hvid engine throughout the working or expansion stroke. At

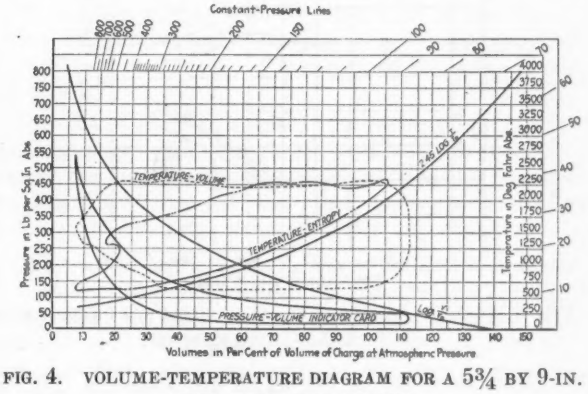


FIG. 4. VOLUME-TEMPERATURE DIAGRAM FOR A 5¾ BY 9-IN. HVID KEROSENE ENGINE

first glance it might be argued that this sustained temperature would be harmful because of undue heat losses to the water jackets, but since the water-jacket losses are low and the thermal efficiency of the engine is remarkably good, the writer believes that combustion in the Hvid engines takes place in the form of zone burning and that the cylinder walls are more or less insulated from the high temperatures of combustion by a layer of air which is not burnt until near the end of the stroke.

The heat balance test gives the mechanical efficiency

and the thermal efficiency for both brake and indicated horsepower. It was made upon a 5¾ by 9-in. single-cylinder Hvid engine which was flexibly connected to a Sprague electric cradle dynamometer by means of two "Spicer" universal joints. Engine speeds and fuel weights were obtained by means of electrically operated appliances. Arrangements were also made for determining the jacket-water loss and the sensible heat of the exhaust gases (calorimeter method). The developed and friction horsepower were determined by means of

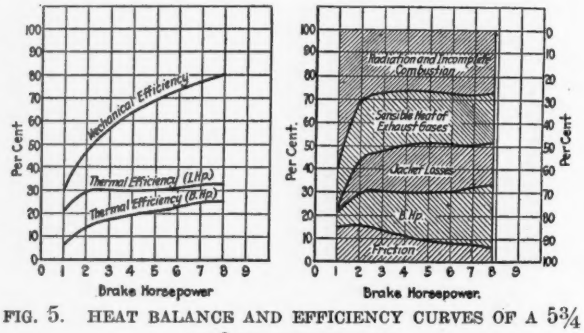


FIG. 5. HEAT BALANCE AND EFFICIENCY CURVES OF A 5¾ BY 9-IN. HVID ENGINE

the dynamometer. Indicator cards were also taken, but because of the probable errors due to the high pressure involved and the comparatively high speed of the engine, these cards were used merely to study the valve settings and general events of the cycle, and not for indicated power measurements. The engine was operated under various loads and speeds with various adjustments of fuel supply, compression and cup design. The final setting was made with a compression of 390 lb. per square inch.

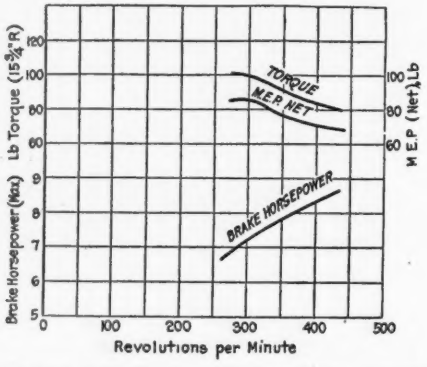


FIG. 6. BRAKE HORSEPOWER AND TORQUE CURVES OF A 5¾ BY 9-IN. HVID ENGINE

Test runs, curves for which are shown in Fig. 5, were conducted at various loads from a maximum to about one-eighth of maximum load.

In Fig. 6 are shown some of the torque characteristics of the Hvid engine. When a gasoline engine of conventional design is overloaded so that the speed drops beyond a certain point its torque drops rapidly, because a certain velocity of air must be maintained through the carburetor to pick up and vaporize the fuel and carry it into the cylinder; but in a Hvid engine, since the introduction of fuel into the cup and into the cylinder is not dependent upon the velocity of the air taken in, as the speed drops, due to overload, more fuel is admitted than at normal speed, because the time element for the introduction of fuel is lengthened and the engine consequently shows remarkable "hanging-on" characteristics.

Under these conditions it is very wasteful of fuel without a doubt, but there are certain conditions where this "bull dog" characteristic is desirable, even at the expense of fuel economy.

The H. C. L.

JUST why the cost of living has risen, and, more important, how it can be brought down, is thus tersely summarized by the Council of National Defense after a most exhaustive investigation:

Causes

THE Nation's productive powers have not been fully utilized since the armistice.

Too few goods, notably the necessities of life, have been produced, and even some of these goods have been withheld from the market, and therefore from the people.

The high cost of living is due in part to unavoidable war waste and increase of money and credit.

There has been and is considerable profiteering, intentional and unintentional.

The Remedies

PRODUCE more goods, and produce them in proportion to the needs of the people.

Stamp out profiteering and stop unnecessary hoarding.

Enforce vigorously present laws and promptly enact such further new laws as are necessary to prevent and punish profiteering and needless hoarding.

Bring about better co-operation and method in distributing and marketing goods.

Keep both producer and consumer fully informed as to what goods are needed and as to what supplies are available, so that production may anticipate the country's demands.—Forbes Magazine.

Pumping Hot Water

WHERE CONDITIONS will not permit placing the boiler feed pump below the heater, and where the pump is some distance from the heater, the following experiment was made with success: A 6-in. pipe 30 in. long was threaded on both ends and capped. The top was tapped out for 1-in. pipe and fitted with a nipple and 1-in. valve, and the other end was tapped the same size as the suction on the pump. A tee was placed near the pump on the suction and the 6-in pipe was put on. By opening the valve on top, the water from the heater would seek its level, and the 6-in. pipe would fill up. This would give a head of water at the pump and prevent it from becoming steam bound.

By placing a 3 by 1-in. reducer above the 1-in. valve to act as a funnel, this 6-in. pipe will be found very useful in introducing compound or boiler preservative into the boiler. This will not hurt the pump and prevents corrosion; also keeps the scale from forming in the feed line.

R. GORDON.

Non-Return or Boiler Check and Stop Valves

NOTES ON SELECTION AND USE. BY CHARLES B. RISLEY

INASMUCH AS non-return valves are intended to serve as safety appliances, a few words of practical experience and caution regarding them is a matter of interest as regards safety and satisfaction of such appliances.

While there are a number of makes of non-return valves on the market, the purchaser who has not studied the defects of such valves is apt to, and sometimes does, purchase valves which embody features that cause trouble and have been known in many cases to fail when emergency called upon them.

On the face of the subject it appears that a check valve in a steam pipe is a very simple thing, and so it is; but when the great amount of trouble manufacturers have encountered in designing these valves to overcome difficulties that arise in service is considered, together with the great amount of trouble and dissatisfaction that has been brought about by complicated combinations of springs, weights, dashpots, pistons, packing glands, friction rings, etc., the device does not appear so simple. Most attendants of boilers find a lack of co-operation from the management, a shortage of help and a demand for a "hurry up" in getting boilers back into service when down for cleaning or repairs; often there is a poor arrangement of valves and piping, and under such conditions the non-return valve is neglected. In fact, I have heard a certain superintendent of a large manufacturing plant remark: "We do not regard the non-return valve as safe. We only put them in to comply with the law." Incidentally, his plant was recently blown to complete destruction from an unknown cause.

It is evident that the design of valves has become entirely too complicated in an effort to overcome the "chatter" of the valve, or to avoid conflict with some patent that might lead into litigation. The writer has had some experience with valves that were among the first types put on the market and has not found that the modern improved valves show much advantage over them.

In considering the purchase of a non-return valve, look into the details to make sure that there are none that may cause friction, get tight or stick. If there is a packing gland through which some part must move, you may assume that such packing glands mean unreliability. I have tried carefully to pack and lubricate such a valve, but the results were not to my satisfaction; therefore, if such a valve is unreliable when given attention, it is likely to be unreliable when in the hands of the average boiler room help or under conditions to which they are subjected. Lever weights or springs are a source of annoyance, as they may become unsettled, and dancing and pounding results, and if externally arranged are accessible to the boiler room help, who may choose to improve the adjustment.

Steam packing or friction rings used upon the dashpot piston are excessively expanded by the high pressure of steam. These rings are sure to become corroded or carbonized from burnt oil or clogged with grit carried by the steam. Close fitting, long pistons are also to be avoided, as a small amout of grit will cause them to stick.

I have never come in contact with non-return valves that did not possess some of these objectionable features, but by fitting the dashpots with a properly designed free fitting piston excluding packing or friction rings, plugging up any port hole in the dash piston and tapping a bypass into the body of the valve in which the bypass is placed a ⅜-in. key type regulating valve to regulate the "chatter" from the exterior of the valve. While in operation I have been able to get excellent results from valves that previously were unsatisfactory, and had failed in emergency when greatly needed. If chattering is so severe that this method does not eliminate it, it may be necessary to change the design of the valve seat, which necessitates replacing the old seat with a new one. In most cases, however, the foregoing will be all that is required.

With valves of the internal dashpot type it is well to tap a hole in the bonnet, and screw a small tallow cup therein, using at intervals a grade of lubricating oil that will not carbonize.

There seems to be a difference of opinion as to the advisability of installing the two-way automatic valve. I can see no reason why such a valve is not extremely desirable, as it is a matter of safety to have a valve that would protect the plant in case of steam pipe accident or explosion, provided, of course, that such valves are designed so that they are satisfactory in operation. In fact, safeguarding the steam piping is a great step toward safety.

Where a number of boilers are in service it is especially desirable to have all steam outlets double valved with the non-return valve attached next to the boiler. With this arrangement the non-return valve may be taken apart and examined at any time the boiler is out of service.

In one of the recent issues of a power plant journal an account of a boiler explosion lays blame to the sticking of the non-return valve, which allowed the pressure to rise above that of the other boilers and finally released it suddenly, accounting for the explosion.

The writer had a rather uneasy experience once when a certain boiler was noticed to register 10 to 15 lb. higher than the other boilers on the line. Steaming was checked until the pressure dropped to normal, then cut out of service. On examination of the non-return valve I found the valve seat loose in the valve body and that it would follow the valve disc when it opened, thus obstructing the flow of steam from the boiler. Had this defect not been noticed and corrected promptly it might have been the cause of mysterious and serious trouble.

In another plant three boilers were equipped with "Y" pattern non-return valves. The boilers had been installed with unprotected blowoff pipes. On three occasions a 2½-in. blowoff pipe burned off and each time the non-return valve failed to cut out. Later the writer took charge of the plant and promptly examined

the non-return valves, which were found to be stuck so firmly that it was necessary to use a block and heavy hammer with a liberal supply of kerosene to get them loose. The pistons were cleaned and the friction or packing rings removed and consigned to the junk pile. The valve bonnets were fitted with oil cups, and these valves have operated properly ever since.

In another case a 6-in. valve was sent to the makers for refitting. It was returned with a snug fitting piston having a ⅞-in. snap ring upon it and a ½-in. port hole drilled through the piston. I plugged this port hole and reduced it to 3/16-in., removed and abandoned the snap ring. The same alterations were made on all other boiler stop valves in the plant and these valves that had failed on every occasion before, and on one very serious occasion, have since worked properly.

New Heating System for Paper Mills

Steam Piping and Pumping Arrangement for Forced Steam Circulation and Closed Loop Boiler Feeding

PAPER manufacturers have experienced considerable difficulty in removing water and air from their dryers, which prevents the circulation of steam through the dryers and causes uneven drying.

This subject has been given considerable study and a new system has been developed by the Farnsworth Co., of Conshohocken, Pa., which overcomes this difficulty and has other advantages.

A high steam velocity through the dryers is effected by the forced steam circulation system which eliminates all water and air and provides a constant, even, known temperature throughout the dryers at all times, which decreases the pressure necessary to dry the paper and permits the speeding up of the machines so as to increase production anywhere from 5 to 10 per cent.

By means of a closed loop boiler feeding system, the condensation from the paper machine and all other heating apparatus and make-up water as well is held under pressure and returned directly into the boilers at a high temperature. These systems eliminate individual traps on the dryers, vacuum pump, receiving tanks, hot wells, boiler feed pumps, much piping and maintenance cost.

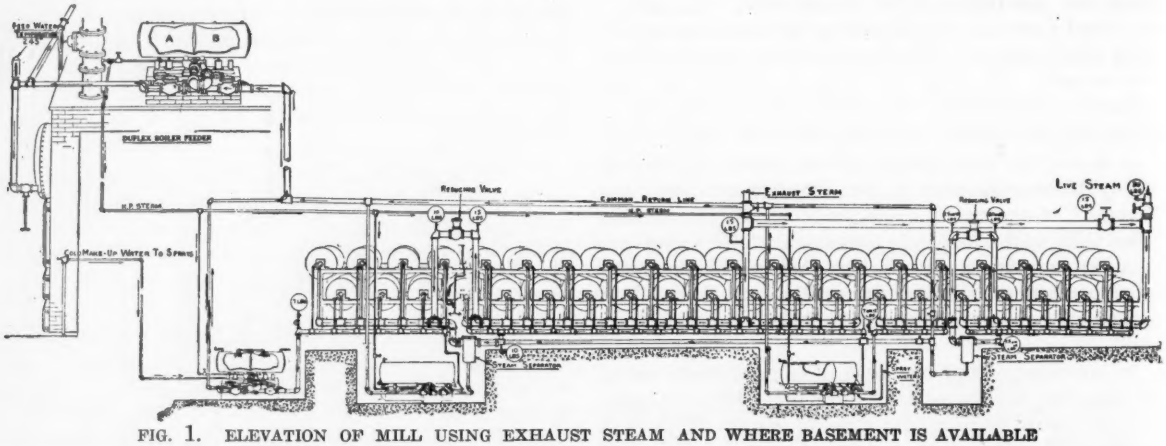


FIG. 1. ELEVATION OF MILL USING EXHAUST STEAM AND WHERE BASEMENT IS AVAILABLE

Figure 1 shows the system applied to a paper machine having a basement underneath it. This system is explained as follows:

The paper machine is divided into two sections, one of these sections to have 75 per cent of the dryers and the other section the remaining 25 per cent. The steam and return headers between the two sections are cut, and a steam separator is placed on the end of the return header for the dry end section which separates the condensation from the steam which has blown out into this portion of the return header. This steam is passed over to supply the steam header for the remaining dryers on the wet end. On the end of the return header for the wet end dryers is placed a duplex condensation pump, condenser vacuum type. This machine has cold water sprays in the top of the tank. The spray water condenses the vapors in the return line, producing a forced steam circulation.

In other words, exhaust steam enters the dry end of the paper machine and passes through the dryers on the dry end at a high velocity, due to the condensing of the steam in the wet end section, assisted by the vacuum produced by the condensing sprays in the duplex condensation pump on the end of the return line for the wet end section. This also produces a high velocity of steam through the wet end section, with the result that water and air are eliminated from both sections and a constant, even, known temperature at all times is produced.

The dryers on the dry end are hottest with a gradual decrease in temperature as the wet end is approached.

If for any reason insufficient steam should pass through the steam separator to maintain the required pressure in the wet end section, steam is bypassed through a reducing valve and the proper amount is supplied.

Summing up, therefore, the steam supply line for the paper machine is connected at or near the beginning of the dry end. Steam is allowed to blow through all the dryers in the dry end section and out into the return line, carrying with it all the water and air in these

dryers. These dryers are, therefore, nothing more than the steam supply line for the dryers on the wet end.

The condensation is then separated from the steam that has blown through and this steam is passed over to supply the dryers on the wet end section. The condensation that collects in the separator is drained into a simplex condensation pump. The air which enters the receiving chamber of each machine escapes through the vent.

In the closed loop boiler feeding system, the condensation which is collected in the simplex condensation pump and in the duplex condensation pump, condenser vacuum type, is pumped automatically during the operation of the machine to the receiving chamber of the duplex boiler feed located from 3 to 10 ft. above the high water line of the boilers.

The duplex boiler feeder has two chambers, one of which is always receiving while the other is delivering the condensation with all its latent heat directly into the boilers, giving a high feed-water temperature and consequent saving.

Condensation from all high-pressure traps is discharged directly into the line leading to the receiving chamber of the duplex boiler feeder. The condesation from all low-pressure heating systems, fan coils, etc., is drained into simplex or duplex condensation pumps and is forced up to the receiving chamber of the duplex boiler feeder by the application of live steam on the surface of the condensate in the tank while it is in the receiving position.

The closed loop boiler feeding system is an efficient method for handling condensation because the pressure is never relieved from the surface, which would lower the temperature to correspond with the decreased pressure.

Figure 2 shows the systems applied to mill using live steam in the dry end containing ⅓ of the total number of dryers; the remainder of the dryers are supplied with exhaust steam. In this case, the machines which drain the paper machine are set in pits, as there is no basement underneath the paper machine.

Under these conditions, the live steam division of the paper machine and the exhaust steam division are each divided as in the case of Fig. 1; that is to say, each division is sub-divided into two sections, one section to have 75 per cent of the dryers, and the remaining section 25 per cent.

With this arrangement, live steam blows through the first section on the dry end and out into the return line at a high velocity. It passes through a steam separator and over into the second section of the dry end, where it is condensed and this condensing effect, assisted by the simplex condensation pump, condenser vacuum type, on the end of the return line, produces a forced steam circulation system through both sections.

The exhaust steam division of this paper machine is handled exactly as described for Fig. 1.

The dryers on the dry end are hottest with a gradual decrease in temperature as the wet end is approached. The hot dryers on the dry end set the paper as it leaves the paper machine. The condensation which is drained into the separator on the live steam dryers is forced to the receiving chamber of the duplex boiler feeder by the pressure carried on the dryers.

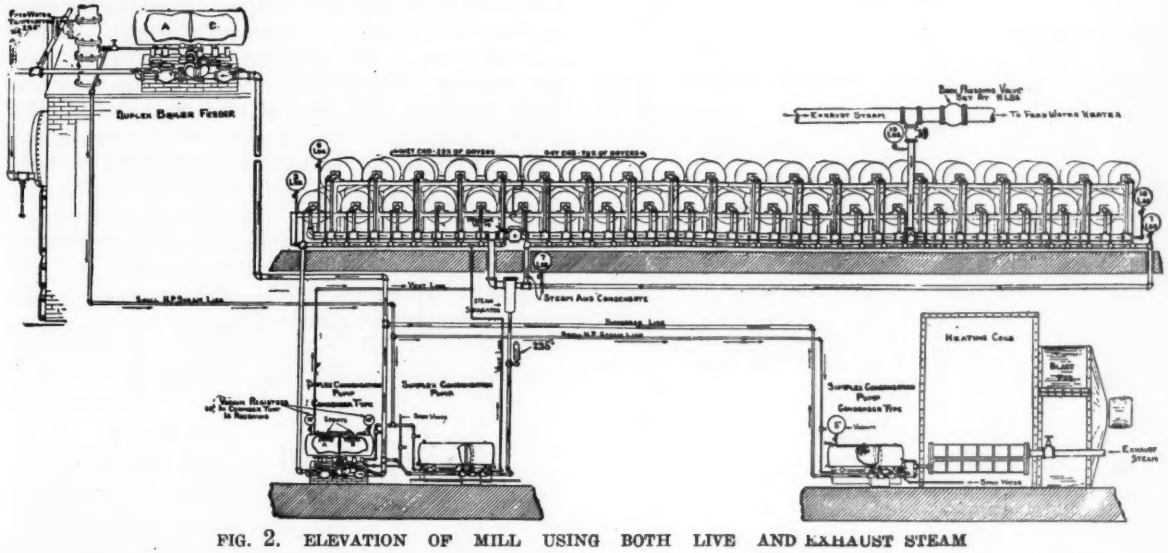
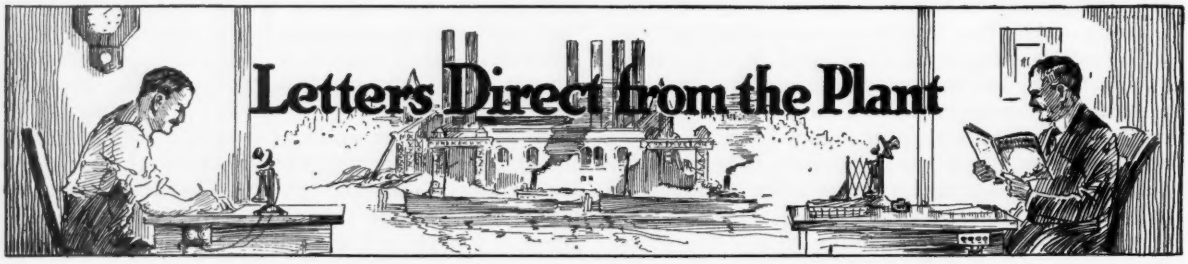


FIG. 2. ELEVATION OF MILL USING BOTH LIVE AND EXHAUST STEAM

The other three machines pump the condensate to the receiving chamber of the duplex boiler feed and, as previously stated, all the condensation with its valuable heat units is delivered directly into the boilers.

COMMITTEE ON STATISTICS of the Chamber of Commerce of U. S., in its annual end-of-the-year review of business and crop conditions, predicts continued industrial activity. The report states that manufacturers have orders in excess of their capacity, and in retail trade there is a feeling of confidence of continuation, until another harvest at least, of demand for all classes of commodities.

IT IS ESTIMATED by the U. S. Geological Survey that 35,974,000 bbl. of domestic crude petroleum was delivered to consumers in November, 1919. The average daily rate of consumption of domestic petroleum in that month was 1,199,133, an increase of about 6 per cent, compared with the rate of consumption in October, 1919.



Faulty Feed Water Piping

SOMETIMES AN ACCIDENT will show us mistakes that have been made, when we would never have discovered them otherwise. I have in mind something that occurred in our plant recently, of which I want to give other engineers the benefit. The two sketches will show the original system of supplying our feed water, and the present arrangement of the piping. They will also show that it is sometimes a loss to try to increase the temperature of the feed water, if all other conditions and circumstances are not considered.

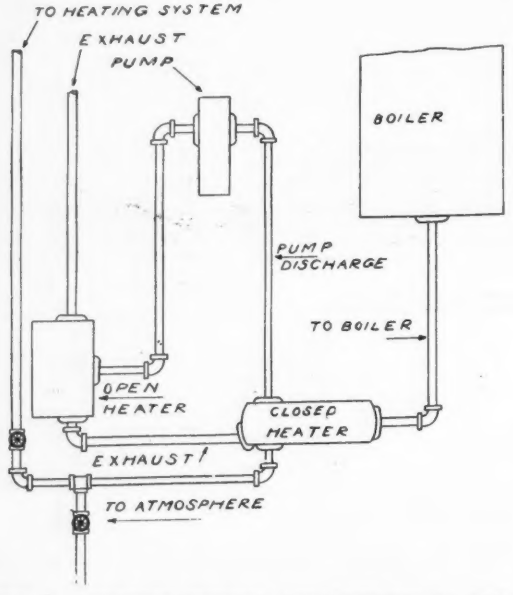


FIG. 1. SHOWING ORIGINAL ARRANGEMENT OF FEED WATER PIPING

When I took charge of this plant, I found that the feed water was being drawn from an open heater. From there it passed through the boiler feed pump, through a closed type heater, thence to boiler. On account of the peculiar construction of the boiler room, pump, heaters, etc., were very poorly arranged causing the pipe system to be made up in such a manner that there were exactly 22 ells or tees in the line between the open heater and where the water entered the boiler. It is impossible for me to make the sketch showing all these turns or try to explain just why they were necessary if the two heaters were used.

We use the exhaust steam for heating the building. One morning, when I came on duty, the assistant engineer, who has charge at night, reported that the main boiler feed pump had given him trouble all night; that if he allowed it to run fast, it would pump all right, but that he could not keep it running just fast enough to keep the correct water level constantly, and that he had to pump up to three gages and then shut down, as it simply wouldn't run slow. The other pump had been taken down a few days before to be overhauled, so we were up against it.

My examination of the pump showed a broken ring. The machine shop could not have one ready until the next day. Without thinking much about what I was really doing, I cut out the closed heater and bypassed the water as in Fig. 2. I started the pump up and to my surprise found that it ran smoothly and regulated perfectly. As a coal shortage was threatened, I had been making a few calculations concerning the heating of the building. We need about 3 lb. pressure on the system. I had calculated the amount of steam that the engines were using, then the amount really needed to

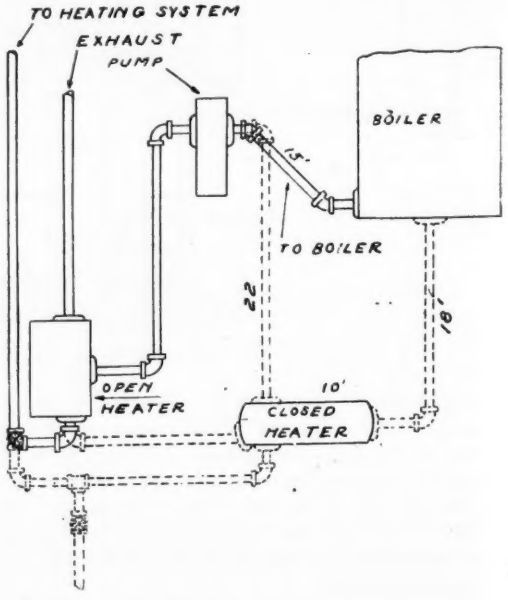


FIG. 2. ARRANGEMENT WHICH GAVE GOOD RESULTS

heat the building, and, according to my calculations that I knew should be right, there should be more exhaust steam available than was necessary to heat the building. I had been using live steam right along, as the exhaust simply did not heat the building. I wanted to cut out this live steam, as every rule showed that I should have enough exhaust. I couldn't figure where that exhaust was going. There were no leaks. All traps were examined and found O.K.

While thinking over the matter, I went back to see

how the feed pump was getting along and noticed the pressure gage on the heating system showed 5 lb. pressure. I cut out all live steam and opened a valve, blowing the system down to 2 lb. In about 30 min. the gage showed 5 lb. again.

I got busy to figure this out, and this is the explanation: My open heater was raising the temperature of the feed water to from 200 to 204 deg. The closed heater was bringing it up to 212 deg. The way the piping was arranged to pass the exhaust through the closed heater, the temperature of the steam was lowered so much and circulation to the heating system was retarded so much that there were not enough heat units left to be of much value, a big portion passing out as condensate through the trap to the receiver before it ever reached the heating systems. Also the feed water line was so badly arranged that the resistance in the line required a large amount of steam through the pump to overcome it.

To be sure that I was not making a mistake in cutting out the closed heater, as soon as I could get the new ring in the pump, I ran a test with the heater on and used the necessary amount of live steam on the heating system to maintain 3 lb., then ran a test with the closed heater cut out, and the result was 510 lb. of coal per 24 hr. saved without the heater. During the last test it was necessary to keep a small bleeder valve on the heating system open in order that the pressure would not go above 3 lb.

Not taking the heating system into consideration, I find by actual test that it costs me as much fuel to pump the water through the closed heater arrangement as the increased temperature of the feed water saves me. Now, if the open heater, pump, closed heater, etc., could be installed or arranged in a fairly direct line without so much piping and bends, I am sure that the closed heater in connection with the open heater would be a good plan, but, under conditions here, it is certainly a disadvantage.

H. A. CRANFORD.

Did the Engine Run Too Fast?

I HAVE read every letter printed in this magazine on the above subject. It has been pro and con. Let us forget the size of the wheel, engine, or any figures. Let us take up engine room conditions and what we must develop power with. We do not sit down to find out how fast the flywheel is traveling, but the power we must get out of the engine to produce the energy for the factory.

There are many engineers who pride themselves on saying, "I made her work; I pulled the factory during the war and did 300 hp. with a 150-hp. engine. I wouldn't care if they had piled more on me."

Now then, let us run an engine at a certain speed or a maximum speed set by the governor, which is the safety limit. The factory has to produce more. They install more machinery, paying no attention to the output of the engine. The overload comes on, which slacks down the engine and reduces the voltage on the generator; machinery out in the factory is also slowing down; production dropping off. Now, Mr. Engineer, you are going to have some visitors or telephone calls from the manager and foreman. It is no use to say, "I can't"; you use your mind.

Well, the old engine is doing her best; but we must get a little more speed to keep up the voltage. We turn to the governor; to overcome this peak, we take a little harmless stick of wood and block the governor, and away goes the engine. Voltage up to standard; no telephone call and everything going along fine. You certainly are proud and tell some of your fellow engineers what a load you are carrying on your engine. I do not blame you; that is the way the American engineers run their machines, to get every ounce of energy out of them.

Now, everything has been running in shipshape manner. We will say that here a circuit breaker jumps out, either from a short or overload. This lightens the load on the engine, the engine in turn speeds up and the generator voltage increases. This causes some more load to drop off. The speed of the engine increases as the load keeps falling off.

Let us look back to the governor. What happens here? "Oh, nothing." That little harmless stick or wedge is still holding the governor as we wanted it to do. We are now getting speed. Here I will stop and let you figure it out for yourself.

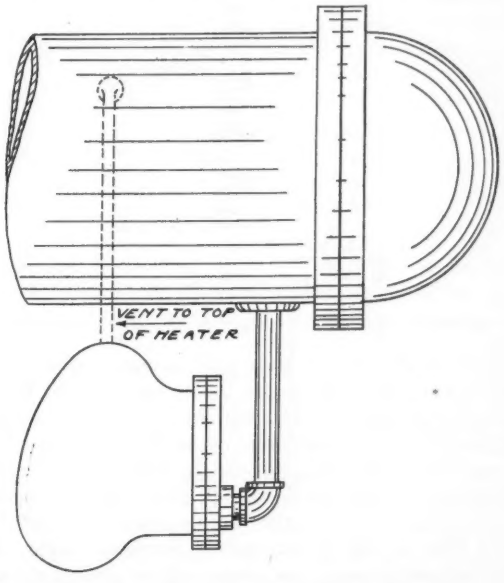
This is just a reminder of what nearly every old engineer has done in his running experiences.

What will cause the engine to run away without losing some load, this load being an overload on the engine and speed below the regular speed, the load holding her down?

C. W. SPAHR.

Venting Low-Pressure Traps

A FREQUENT cause of trouble in low-pressure traps, is the pressure of air pockets, emphasizing the importance of venting the trap back to the steam line drained,



METHOD OF VENTING TO CLOSED HEATER

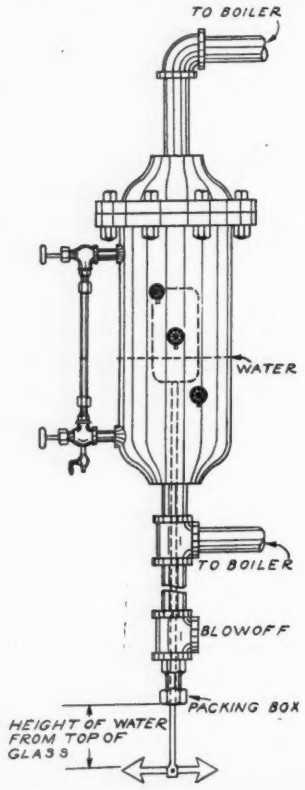
or fitting the trap with a pet cock or valve for blowing off the air and accumulated gases from time to time. Where only a limited head is available the matter of venting is of importance because it helps to balance the pressures and gives the drainage system the full benefit of the drainage head available. Some time ago we decided to try to save the condensation from our closed

heater by putting in a trap to drain it. There was only a 2-ft. head available, so the trap never gave satisfactory service until we ran a ¾-in. vent line from the trap back to the shell of the heater. Whenever trouble has been experienced with drainage traps, working under low heads, it is advisable to look into the method of venting because if this is overlooked trouble from air locking or reduced head is likely to be encountered.

M. A. SALLER.

Water Level Indicator

IN PAST DAYS when practically all steam packing for valve boxes was composed of cotton, rubber and other material, an awful howl would be made by some journal



ARRANGEMENT OF INDICATOR ON GAGE COLUMN

readers if any writer suggested using a packing in a valve box if the valve was to be operated by a float. There are many men who still have that idea so firmly instilled in their minds that it is almost useless to try to convince them that this old idea should be modified somewhat. With a modern high grade metallic packing, properly used, the friction on the valve rod will be so small that it can be ignored in practical work. Even after several years in use, valve rods so packed are steam tight and the friction is only slightly increased. The reason for this preamble is that such a packed rod is used in the idea shown by the accompanying sketch.

On some boilers, the water column is so high that the boiler fireman has difficulty in quickly noting the height of the water in the glass. A column is used containing a float to which is attached a ⅛-in. brass, bronze, or nickel rod, with a pointer, B, attached to the lower end. This pointer can be set at about the level of the fireman's eyes. The length of the rod showing below the packing box is the distance the water is down from the top of the glass.

Once a week or so, the fireman can move the rod up and down with his finger to be certain that the rod is not binding. As stated, the probability of the rod binding is almost nil; but it is only a second's work to make certain, for no piece of apparatus is absolutely perfect. No further written description is necessary to explain the sketch.

JOHN THOM.

Ignorance in the Power House as Viewed From Another Angle

THE WRITER of the article entitled, "Ignorance in the Power House," has brought to light an important and true condition which is in existence throughout the country in a great many power houses; but he used as an example a case dealing with a man who had not yet received an engineer's license and from what he said of this man, the chances for his ever receiving one are very small. In this article, the writer has taken as an example one of the many cases also in existence throughout the country where men who are holding as high as first class licenses exhibit considerable ignorance and the question arises, what should be thought of them —men who manage to procure a license and then don't know how to use it. Simply getting and hanging an engineer's license in the engine room is not using it nor is it any sign that the owner is going to be guaranteed by its presence the ability to perform the duties required of him in accordance with the class of license which he holds.

How many men simply "dig into a book" just long enough to pass an examination and receive an engineer's license and then forget to realize that they have considerable to learn and keep learning in order to uphold that license? You need not go far from where you are to find many cases of just such men who simply get a license and then quit; quit study, quit taking information from those who do know and quit following the proper methods laid down for operation of power plants, and, as a matter of fact, quit everything except a keen lookout for the men expected to relieve them, and pay day. There are many such men who are holding licenses and not living up to them. They are a much worse class of men than those in the class mentioned by "Red Man" in the Nov. 15 issue—unlicensed men. Red Man mentioned his case to show why there should be a nation-wide license law. In view of the existing condition among men who have passed examination and received licenses, I ask what good is a nation-wide license law going to do when you get right down to the heart of the situation?

I am not meaning to insinuate that it is my desire to oppose a nation-wide license law, because if such law were enacted there could be no doubt but that great good would be done; but I may add that if such were to come to pass, the law should be such that there would be less simply getting by and getting a license and then filling the country with men who have only that one desire and then quit. I will explain what I believe could be done in order to bring about that important result later. To cite a few cases where men who hold licenses

are remarkably ignorant on the fundamental principles of engineering, I shall tell you of several cases which concern men who each held a first class license.

On visiting a small plant, I found the engineer cleaning his boilers. His method of a thorough job of this kind consisted of simply emptying his boilers, refilling them with fresh water and emptying them again. This he did twice and then washed out the interior with a hose and stream of water which has little or no pressure back of it. He did not scrape out a piece of scale, though there was considerable of it present and baked on good and hard. He then added about 2 gal. of cylinder oil and told the helper to put on the manheads. When asked why he never attempted mechanically to remove the scale he said that it didn't pay, as the water was so hard and ate the tubes up in about so long a time anyway, so that he used only a "little" cylinder oil and blew out what scale the oil dissolved every day until he thought the tubes needed renewing, and the boss thought it was better to buy the new tubes than to go to the extra expense of buying a tube knocker or suitable cleaner which would be needed to remove this hard scale. He could not see that the oil was harmful, nor did he ever think that there was any danger in trying to blow heavy scale through the blowoff, nor of the blowoff becoming obstructed and burning off. A good deal more he never thought of in connection with his improper operation of this plant, though he had a license, hanging on the wall in a frame which must have cost at least $5.

In another case where a first class engineer was in charge, I noticed an attempt on his part to parallel two alternators, one being driven by a Diesel oil engine and the other by a tandem compound high speed steam engine. The oil engine had about full load and the steam unit was coming up to speed. He said he had to get the steam engine started and then run to the board to be synchronized before it gained its normal speed, as he could not regulate either engine's speed from the board. He got the two together apparently O. K.; but all of a sudden, as a little more load came on, there was a long squeak and a noise like the shot of a cannon when the big 24-in. double leather belt snapped off the generator pulley, and the oil engine stalled. Upon an examination of the outlay machinery, I found that with the normal speed of the steam unit and the size pulley on the generator being too small, resulting in an excess frequency, there was no way under the present conditions of paralleling these two units. The frequency of the two could not be made the same and, as a matter of fact, he was driving the oil engine generator as a motor until the extra load came on and caused the trouble. Upon becoming acquainted with the other engineer who was called to help remedy the trouble, I was told that they never did synchronize these units on account of the extra frequency of the steam unit and that the former engineer was "showing off," which I'll say he certainly did. I also learned that there was never any need of running the two machines together, as when the load got too heavy for the oil unit, it was supposed to be shut down and the steam take the load. What kind of engineer would you call this with a first class engineer's license, and not following the proper practices designed for the operation of this plant?

An engineer was taking a pump apart which was used as a general service supply pump and when asked what was wrong, he said there was something wrong with this gol darn pump and that it wouldn't pick up the water. He examined the valves and suction and in fact the entire machine and its parts, but found nothing wrong. Upon reassembling it, he tried to pump water again, but to no avail. The suction ran into the reservoir, which was roofed in, and where the pipes entered the cribbing they were sealed in by concrete. I found that the roof was protected by an extra heavy layer of good gummy dirt apparently having been subjected to considerable good cylinder oil and I asked him if he was sure there was water in the reservoir. His reply was that as he had been there for 5 yr. and had never heard tell of the water running low, he had not taken time to open the trap door. I suggested his opening it anyway and in regard to that he hesitated deliberately on account of the trouble it would be to bother with it just then, but he would try priming the suction. He still pumped no water, so finally he raised the trap door of the roof and in order to do it he had to use a 10 ft. lever. Of course, the partial vacuum which had formed by the well becoming practically sealed, had nothing to do with the trouble although when he started his pump up this time everything was O. K. The atmospheric pressure was using its good influence then.

In another case, a safety valve leaked a good deal when the pressure was near the point where it should be relieved, and the engineer deliberately connected another safety valve in series with it and exhibited considerable glory in having accomplished a great remedy for leaky safety valves. He could not understand that the pressure on his boilers would now have to rise to the point in pressure equal to the sum of the blowing points of the two valves and perhaps a boiler explosion would occur in the meantime. This man also had a license mounted in a handsome frame.

Why do these licensed men do such absurd things in or about the power house? Is it ignorance or do they know better and simply want to exhibit a lot of nerve? In either case, ignorance is the credit they deserve and get.

Now, the question arises as to what law is going to better the actual conditions in power plants where men hold licenses and still are questionable as to their merits for doing so. I believe that a national law is eventually going to be in existence and that it will do good; but I trust that when such law becomes effective, it will provide a means for the men who are assuming the duties of engineers in power houses being kept tab on and liable to a good questioning from time to time by a traveling inspector, and also that an inspector will be handy from time to time to pop in and see how things are kept and see personally what practices are going on in general. This is already in practice in some states and the sooner there is a law where inspectors do not simply give you one examination and issue a license, they will be able to keep record of your performances and if necessary have the privilege of calling more men back "on the carpet" to give them a chance to show cause why they are not subject to having their licenses revoked on account of improper practices in the power house. It may be then and not until then that more men will con-

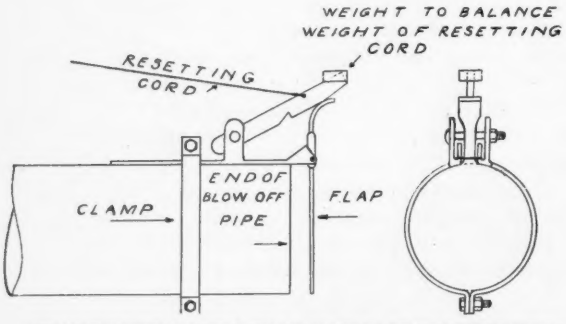
tinue their studies and efforts to regard the proper rules laid down in the history of power house operation for correct practice and efficiency, instead of simply making effort sufficient to procure an engineer's license and then becoming a practical deadhead in the rear rank of would-be engineers with a license and a swelled head.

N. EWING.

Blowoff Telltale

THE HEAD FIREMAN in a certain plant was supposed to blow down his boilers twice a day, once at noon and again during the early evening.

The end of the blowoff pipe emerged from underground at a bend in a nearby creek, some distance, however, from the boiler house. The watching of either the head fireman or the end of the blowoff pipe caused the chief engineer a few cold meals and he was very uncertain as to whether his explicit orders were being obeyed. Rather than remain at the mill during the noon



ARRANGEMENT OF TELL-TALE ON END OF BLOWOFF PIPE

and evening meal hours to watch proceedings, he devised the accompanying tell-tale to prove to himself that things were as they should be.

He now misses no meals and is able to tell whether the boilers receive proper attention or not. When he returns from meals or when he arrives in the morning, all he has to do is to glance at the tell-tale as he passes. If the flap is up, he resets it by pulling the cord; if the flap is still down, the head fireman hears of it in short order.

The device is simple and sure. Try it when you are uncertain.

CONDENSER.

That National License Law

THE ARTICLES on the National License Law in Dec. 1 and Dec. 15 issues have interested me not a little. Having received my training in a state where engineers and firemen are licensed, makes this subject even more interesting to me. But just think how impossible it would be to swear every applicant for a license to absolute secrecy regarding the questions asked by the examiners; and, also, ask the practical chief whether he would favor a man who would answer the questions 100 per cent strong or the man who really knew a steam plant from start to finish.

Several years ago, a case came to my attention where an engineer was granted an unlimited license. This man had never even worked in a plant requiring first class engineer's license and his practical experience was gained in a plant of not over 50 hp.; yet he was able to answer the questions, and set the valves on a small Corliss engine. Although this man was studious and had fitted himself for a chief's berth, his practical experience qualified him only for a pump operator in a large plant.

Shall a National Board license the man who can answer the questions, or shall the board look up the applicant's qualifications?

Now, regarding the bookkeeper.

One business man asked: "Why are engineers not like bookkeepers? A good bookkeeper gets a good salary; a poor one gets a small salary." What is a good bookkeeper?

A good bookkeeper is a man who is accurate at figures and can keep a set of books covering many accounts. The more accounts he can handle, the better his rating.

My experience from beginning to the present time has been that the engineer's salary is generally fully as good as the bookkeeper's. Now, what is a good engineer?

A good engineer is a man who is accurate at figures and can keep a plant consisting of much machinery in good condition. The larger the plant he can keep in operation, the better his rating.

How could the government say what salary a private individual should pay for an engineer's service?

A National License would be a good thing for the engineer with a roving disposition, but the state license covers the engineer who is satisfied to stay at home.

In trying to pass an enactment licensing power plant employes, the difficulty has always been to get around the aforesaid business man. Does he want the government to tie him down to hiring only a licensed engineer?

He does not!

He prefers to hire whom he chooses at the lowest possible rate and this is the stumbling block that Mr. Cranford has to reckon with. Incidentally, some of us have taken courses in bookkeeping and find that as a side line mighty handy at times.

But, as L. W. Reed says: "Let us get together as men and help each other, and all work toward the enactment of a National Engineers' License Law." It can't possibly injure the 100 per cent engineers!

Let us show the bookkeeper a thing or two.

TOM THUMB.

HAVING READ carefully Mr. Cranford's article on the "real license," I see this objection to it: In all probability each of those 10 or 20 engineers of his commission have specialized on some particular branch. Each man's questions would, therefore, be most searching in his own pet subject, questions which even his collaborators would not always be able to answer. In fact, I have never met any really good engineer that said he was 100 per cent in the various branches of power plant engineering.

For instance, I know one man, a wizard with an engine, but I have also seen his furnaces and boilers. Another I know, an excellent man as a master mechanic or electrician; boilers about 40 per cent efficient. As for myself, while I know some little about combustion, that being my pet subject, and can handle the ordinary industrial plant satisfactorily, I am afraid I would have to come below 100 per cent, as I do not know it all, and realize that I do not. How many of us do?

WM. CHADDICK.

Christmas Trees

IN WRITING this, my thoughts revert to a confab I overheard between the superintendent and his foreman concerning a little accident that occurred Christmas Eve.

The foreman made his report of an accident which was more or less due to somebody's carelessness.

"Well, there was nobody killed, eh?"

"No, sir."

"Well, I would like to kill the fellow that said there was no Santa Claus."

The Christmas spirit prevailed, the usual "bawling out" was forgotten, and I felt that I would like to have assisted the superintendent in his destruction of the "kill-joy."

I have told the foregoing incident so that nobody will misjudge the sentiments that prompt me, for I am sure that Santa Claus liveth; in fact, I know his address.

However, I also know that our woods and forests are being sadly mistreated by the cutting down of young cedars, conifers, etc., the purpose being Christmas trees for the kiddies.

While I shall not attempt to give exact figures—that is unnecessary—it is no doubt true that the cutting of these trees every wear means that nature's work of 10 yr. has been destroyed; for, as soon as the Yuletide has flown, these young green trees are thrown away, being too green to burn and too small for cabinet or carpenter work.

How much longer are we going to allow this thing to go on? What are we going to do to stop this tree destruction? It is a long while until our next Christmas trees are needed, and we have that time to construct folding trees which can and should be sold for almost the price that the profiteers charged for the young trees that were so ruthlessly torn from our woodlands. These folding trees will last for years and can be stored in the attic or any place which will give the necessary protection from the weather, a little green paint now and then doing the rest.

The kiddies—God bless them—are not much interested whether the tree bears the greenness of spring or the golden of autumn. Their little eyes, minds and hearts are bewildered with the decorations, and as our trees carry an intermingling of colors, so do their little minds carry such an intermingling of joy that the color of the tree—*per se*—is no factor, and even if it were, the wrapping of the folding trees with some green paper, spangles, dangles, toys, etc., performs the miracle of changing an ordinary piece of wood back to a young green tree.

I have seen a vast number of the young conifers thrown in a field to dry, or rot, just whichever time sees fit to bring, the hoggishness of the despoiler being so great that he has cut down more of these children of the mountains than he could sell, and then when Christmas came, having no further use for the little trees, he cast them off. Think of it and you will see what prompts my writing.

To those who have been intrusted with the protection of the woodlands, the zone where the pirates have operated or will operate, can be easily obtained and a few shotguns in front of a few determined men will stop it in some places, and Uncle Sam should do the rest.

If the folding tree should become universal—and it should, in fact, be compulsory to those that wish trees (I hope everybody had one)—then think of the fond memories that would hover around each particular folding tree.

You will hear Granddaddy tell one of his old friends how Buddy got his little nightie caught on that particular branch while he was trying to reach the drum and that he pulled so hard he came near upsetting it all.

"Who is Buddy?"

"Yourself. Your own little ones are now around that same tree that years agone Santa Claus gave you, and though Santa is older than you or your Granddaddy, he still brings joy to that same tree, and the woodlands have not heard the sound or felt the pain of the despoiler's axe, because there has been no need, Santa Claus having found a method of making trees out of scrap lumber."

The need for tree preservation is so obvious that there is no need to tell it. The remarks herein are true. The suggestion has been honestly and fearlessly given to a body of brainy men—the readers of Power Plant Engineering—and among them, I believe, will be found some progressive enough to make the folding tree a reality.

There are many ways to construct such things, but the most simple in detail and lasting in action will prove the favorite, if all thoughts of excessive profits are forgotten.

If the press of our cities would take this matter up seriously, it would take root and such root would grow a folding tree into the only sanctioned Christmas tree.

J. B. DILLON.

Overcoming Buckeye Engine Troubles

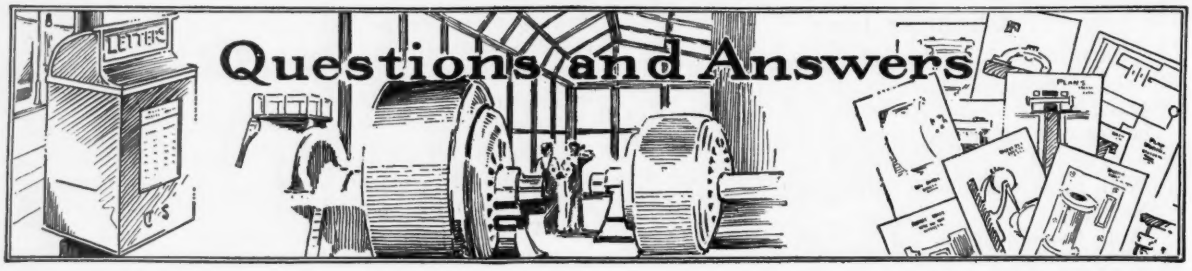
TWO CASES of Buckeye engine trouble recently came to my notice; in both instances the engine used too much steam, so much in fact, that it caused much heavier firing in the boiler room.

In the first case, the indicator was applied, and the valves adjusted; but that did not overcome the difficulty. An expert was called and he found, upon removing the top cover of the valve chest, a hole in the valve. This had been tapped for an eyebolt, used in lifting out the valve; the eyebolt had been removed and the hole plugged. The plug had eventually worked out, allowing live steam to flow through into the exhaust. The hole was again plugged and the trouble remedied.

In the second case, this engine also used too much steam. The valves were taken out and examined and it was found that the riding cutoff valve did not meet edge of port squarely; that is, when the valve was closing, the steam edges on one end were line to line at the top and a quarter inch open at the bottom, while at the other end they were line to line at bottom, and a quarter inch open at top. It was judged that something had got in the port and gave the valve a kink. The riding cutoff, being two flat castings fastened by two rods, is easily sprung. By means of a small bar, the valve was changed so that the edges came line to line.

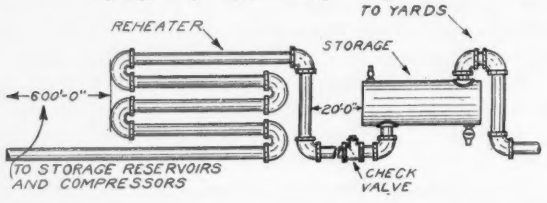
TOM JONES.

STEPS taken by Commission to get at an accurate basis for determining cost of production abroad and in United States are outlined in the report of the Tariff Commission.



Will Gas Form in Storage Tank?

WE HAVE had considerable trouble during extremely cold weather on account of air tools freezing up. In order to overcome this trouble we installed a re-heater, which has given very good results. The only thing that we are afraid of is the possibility of an explosion, due to gas forming in the storage tank located about 20 ft. from the re-heater. We thought the air might become heated to such a temperature as to create a gas from



SHOWING LOCATION OF RE-HEATER AND STORAGE TANK

the oil that is carried to the storage tank from the compressor. We have placed a check valve between the re-heater and the storage tank with the thought in mind that this would prevent gas from backing up from storage tanks to re-heater, where it might be ignited. We use old wood to build fire around the re-heater, which at times gets heated to quite a high degree.

W. W. W.

Peculiar Engine Performance

I HAVE a 25-kw. Ridgeway engine. It has been running nicely until one night recently, when I shifted the load onto it, I heard a knock in the guides. I shut down and turned the engine over by hand, and found that when back dead center was passed a binding occurred. I took the cylinder head off, took out the piston and found everything all right. I readjusted the guides and did all I thought could be done, but without avail. I then lengthened the piston rod one turn and the engine runs all right now. What could cause the engine to act in that way? D. G.

Oil Burning Equipment Steam Consumption

WHEN USING crude oil for fuel, what per cent of the steam generated is required for atomization and other purposes? H. W. G.

A. With reference to the per cent of steam generated and used for atomization purposes in a plant employing crude oil, it is found that with a good type of steam atomizing burner the steam required for atomization is less than 2 per cent of the total steam generated; this under the conditions that the boiler is running at its rated capacity. Of course, this figure would have a tendency to increase as the boiler rating decreases and vice versa. The steam required by mechanical burners in heating and pumping is in the neighborhood of one-fourth of 1 per cent of the total generated and this steam can be returned to the system.

Stopping Seam Leaks

ONE OF my Kewanee boilers has a leak in the seam just inside the firebox door; also a leak around one of the stay bolts in the rear of the boiler near the hand hole plate. As the boiler is in service all the time, except when being washed out, I want to know the quickest way to make these repairs, as I am always in a hurry when I wash out the boiler. D. G.

Why the Snow-Like Ice?

I AM IN CHARGE of an ice plant, and am anxious to know the cause of the following conditions in our plant: Why does the presence of air in ice cause it to be snow-like in color? We are making lots of this white ice, still no one can explain why it becomes so snow-like. Any information you may be able to give me will be much appreciated. J. W. D.

A. Presence of air in distilled water will make opaque ice, but it seldom happens that air alone will make distilled water ice white or snow-like. A small amount of air, unmixed with any other gases, will make a thin white core in the center of the cake of ice, and from this core will be plainly visible the unfrozen needle-like streaks of air. The air needles are colorless.

When a large amount of air is allowed to enter the distilled water the ice will be murky in appearance and may even be called snowlike in extreme cases; but when this condition exists, the air leak will be so large that it is easily located.

If an engineer will trace out the distilled water line from where it leaves the reboiler till the can filler is reached, it will be seen that it is almost impossible for any great quantity of air to get in.

The distilled water is taken from the bottom of the reboiler and if the reboiler is never allowed to become empty, air cannot enter at this point. Watch the reboiler and do not allow the water to be drawn down any lower than 6 or 8 in. below the overflow funnel. If the reboiler is of the shallow rectangular type, do not lower the water more than 2 in. below the overflow. Put a float in the reboiler and a tell-tale weight in such a position that the ice puller can watch the water level in the reboiler at all times.

It is a mistake to put a float valve on the distilled water line leaving the reboiler. If a float valve is at this point and the water is drawn low, the valve will

close so as to prevent emptying of the reboiler. While this valve is closed, the water in the distilled water system will seek a common level; that is, the water will settle down. This will create a vacuum in the highest points of the pipe work. While this settling of the water is taking place, air will enter through such small leaks as are found at valve stems; and this air leakage is almost certain to occur at the valve stem of the float valve.

If there is a float valve at this point of the system, take it out or block it wide open. If it is left in place, be sure that the valve stem is packed with extra good packing and that the packing gland is tight.

The next place where air is liable to enter is at the flat coils. This can happen, but it should be made impossible at the first opportunity. Notice the location of the flat coils in their relation to the reboiler and forecooler. The highest point of the flat coils should be below the water level in the forecooler. The reboiler should be placed high enough to give the water sufficient head to allow for gravity flow when the flat coils are set below the forecooler.

If it is the practice to blow out the flat coils with steam, be sure to leave the drain valve and air vent wide open for several minutes after the steam is shut off and the cold water turned over the coils. Then, when the coil is cool, allow the distilled water to flow in slowly, so that the air will be driven out ahead of the water. Fast filling will allow the air that is in the coil to mix with the incoming distilled water.

Do not steam out the flat coils unless you are sure that it is necessary. If a good grade of cylinder oil is used and the grease extractor (oil trap or separator) on the exhaust line is working properly, and the oil that collects on the water in the reboiler is allowed to skim at regular intervals, there is no need of steaming the flat coils from the beginning to the end of the season.

If the flat coil is connected up for blowing with steam, disconnect the steam line and plug the openings. If you have been in the habit of blowing the coils, just stop doing it for at least two weeks. It is worth trying.

If there are any filters in any part of the distilled water system, they should be disconnected.

Chances of air leakage at the forecooler are slight. It must be provided with a gage glass or float and telltale weight so that the water level can be watched at all times. This level should be high enough so that the ammonia coils are always submerged. If part of the coil is above water, frost will collect and when the water level is raised, the air and gases contained in the frost will mix with the distilled water.

The water line from the flat coils to the forecooler should be extended down so that the water is discharged at least halfway between the water level and the bottom of the forecooler.

If a float valve has any place at all in the system, the forecooler is the proper place. Here the float can be arranged so that the valve will be all under water at all times. This will absolutely prevent any air entering at the valve stem. In this position, the valve will act on the flow of water at the lowest point and when the valve closes, there is no chance of a vacuum in any part of the line. The water leaves the forecooler at the bottom, so air cannot enter this line if the water level is properly maintained.

The packing box at the top of the can filler must be kept snugly packed with good soft packing that is well lubricated. Keep this packing nut as tight as possible without binding the valve stem.

Another point where air can mix with distilled water and cause white ice is at the bottom of the can filler. This space should be as small as possible and still allow free passage of the water. If lugs or projections hold the filler up so high that the can will fill with an inch of water before the air mixing is stopped, the lugs should be cut down.

How small this bottom opening can be will depend on how many cans an hour are filled. Reduce the space to ¼ in. if not more than six cans are filled each hour.

Raw water of any kind mixing with the distilled water will cause regular snow-ball ice. Raw water in this case means moisture contained in the steam just as well as cold water. First: The water, in the form of heavily saturated steam, that is carried from the boiler to the engine with the steam. All steam that is not reheated after rising from the water is saturated; but the degree of saturation (amount of moisture contained in the steam) is excessive at times, owing to such things as high water, dirty boilers, too small steam lines and the overloading of the boilers.

The steam leaving the boilers should be as dry as possible, and the steam that condenses in the steam lines, engine cylinder and exhaust line should be allowed to escape to the sewer through the drain on the separator on the exhaust line. This drain line should not have a valve on it. The steam must enter the steam condenser as free of moisture as possible. All moisture that enters the steam condenser must be considered as raw water.

This same raw water will mix with the distilled water in the reboiler by way of the steam coil, if the coil is of the open or perforated style. The coil should be tight and the full boiler pressure should be on it. The inlet valve is left wide open and the rate of reboiling is regulated by the valve at the outlet. Steam for the reboiler coil should be taken from the top of the main steam line and not direct from the boiler shell or from the end of a line.

Another cause of raw water entering the steam condenser may be in the way that an open-type feed-water heater is connected to the exhaust line. A careful examination of the heater connections will show plainly whether it is possible to lift water out of the heater and pass it along with the steam to the condenser.

The next, and most common, point of raw water mixing is at the steam condenser itself. Leaks are often found in the piping or shell of the condenser and the raw circulating water goes in and mixes with the distilled water. As a rule, there is at least 3 lb. pressure on the condenser, but this does not keep the water out. The condenser breathes, and this breathing will actually draw the outside water in. Leaks in the flask type condenser can be repaired with rivets or toggle bolts.

Double-pipe steam condensers, flat coils and all other double-pipe arrangements must be watched closely for the leakage of raw water into the system.

Gases liberated from the water in the boiler will pass to the steam condenser and again enter the water during the condensation of the exhaust steam. Keep the gas relief on the condensers blowing enough at all times to let the gases escape. A. G. SOLOMON.

Gear Calculations, Boiler Horsepower, Etc.

WILL YOU please explain the method of calculating gear pitch? Suppose I want to cut a gear having 30 teeth, what size and pitch should I make it?

2. I also would like to know how to figure boiler horsepower.

3. How can I calculate the weight of iron and steel shafting? W. G.

ANSWERS

THERE ARE two standards in use at the present time in the measurement of gears. Either the circumferential pitch is used or the diametral pitch. The circumferential pitch is the distance from center to center of two adjacent teeth measured on the pitch circle.

The diametral pitch is the number of teeth on gear divided by its diameter in inches on the pitch line. In the example which you give, the size of the gear and its pitch would be variable within wide limits, for instance a 30-tooth gear whose diametral pitch is 30 would be one inch in diameter, while if the diametral pitch were 15, the gear would be 2 in. in diameter. Another factor deciding the size of the gear is the gears with which it may be used.

In case your existing gears are 4-pitch for instance, the new gear would have to be necessarily of the same pitch and in the case which you mention, we have a diameter of 7½ in.

2. The standard boiler horsepower is found by the following formula:

$$\text{H. P.} = \frac{W \times (H - t + 32)}{3333 \text{ deg.}}$$

In which, H.P.= the horsepower.

W = weight of water in pounds actually evaporated per hour.

H = total heat of steam above 32 deg. F. at the pressure of evaporation, B.t.u.

t = the temperature of the feed water.

A boiler evaporates 3000 lb. of water per hour from a feed-water temperature of 100 deg. F. into steam of 85 lb. gage pressure, what is the standard horsepower?

The absolute steam pressure is 85 plus 15 or 100 lb. Referring to a table of properties of saturated steam, it will be found that the total heat of steam at 100 lb. absolute pressure is, in round numbers, 1182 B.t.u. The statement becomes:

$$\text{H.P.} = \frac{300 \times (1182 - 100 + 32)}{3333 \text{ deg.}} = 100 + \text{horsepower.}$$

3. The weight of iron and steel shafting is found by multiplying the square of this diameter by 0.7854, its length in inches and 0.28.

Conditions Essential to Complete Combustion

EXPLAIN FULLY the conditions essential to obtaining complete combustion in a boiler furnace and explain why the failure to maintain each of those conditions will cause losses.

2. Describe two methods for governing the speed of steam engines. Which method is more economical of steam? M. D.

ANSWERS

GIVEN a properly designed furnace, the question of combustion dissolves into furnishing the correct amount of air. This is governed in two ways, one of which is the thickness of the fuel bed, and the other the usual method of regulating by means of dampers and the ash pit doors.

Too small an amount of air will cause a great volume of combustible gases to pass off without being completely burned. Too great an amount of air will cause some of the gases to be cooled materially after leaving the fire to such an extent that they will fail to burn before passing into the uptake. Too much air also creates an access amount of incombustible gas.

2. There are two methods of governing steam engines in general use. One is by means of the governor which alters the cutoff of the valve; the other is the type which diminishes the amount of steam furnished to the engine.

The first type mentioned is the one generally used in engines other than comparatively small ones as the method of altering the cutoff of the valve is preferable to lower the pressure of the steam supplied to the engine.

Reading U Tubes

A CLAIMS that in reading a U tube it is necessary to take the reading between the level of the water in each of the legs; B claims that but one leg of the tube should be read; that is, the reading should be taken from zero to the level of the water in either leg.

Kindly tell me who is correct. A. G. A.

A. In answer to your inquiry relative to the proper method of reading a "U" tube, A is correct, as the difference between the two levels is taken.

Compressed Air and Refrigeration Problems

REPLYING to E. S. R. in the Dec. 15 issue, it is quite possible to eject water from a hole; that is, lift water from a lower to a higher level by means of an air jet, one similar to the steam jet, assuming, of course, that the conditions are right. If a homemade jet is used, however, it will generally be necessary to experiment somewhat with it to get the air orifice correctly proportioned, as usually the first attempt is not successful. The orifice must be correctly designed for a given air pressure to insure best results, and also the point of air discharge through the orifice must be properly placed with relation to the suction inlet to the jet.

Regarding the ammonia compressor problem, it is a little difficult to give exact information in the absence of more data. It would, however, appear that his system is short of ammonia, as if opening the expansion valves (regulating valves) the usual amount, the proper suction pressure cannot be maintained and also if the condensing pressure remains below normal, it generally means that the charge is too low.

There should always be sufficient ammonia in the liquid receiver to insure a liquid seal above the liquid outlet to the freezing tank or cooling coils when the suction pressure is correct for the temperature desired to be maintained. In some plants the return suction gas is used to cool the water before this is put into the ice cans. This water sometimes enters the forecooler at a comparatively high temperature and sometimes the return suction gas is used to cool the liquid ammonia, and in doing this work the suction gas may become highly

superheated and not be cold enough to form a heavy frost on the suction pipe at the compressor; however, I presume that this condition does not exist at the plant under discussion.

A reliable thermometer in the suction return line near the compressor is an excellent guide for compressor operation, as it will show at all times the temperature of the suction gas entering the compressor, and comparing this temperature with that corresponding to the suction pressure indicated by the suction gage (assuming this gage to be correct) will tell whether or not the suction gas is superheated; in this connection, it appears to be pretty well proven that a slight superheat in the suction gas entering the compressor, say 2 to 3 deg., improves the efficiency of the compressor, since it is operating as a dry gas machine. Obviously this superheat should result from useful work, such as cooling water to be frozen, cooling liquid ammonia before the expansion valves, or useful work in storage rooms or freezing tanks, etc., and not be the result of heat taken up from the engine room, tank room, etc., which results from uninsulated suction pipe lines. C. T. B.

I WILL suppose that E. S. R. has a 150-ft. well, that the water averages within 50 ft. of the top, and that the well is either a 4 or 6-in. pipe casing. Run a line down into the well and ascertain just exactly where the water level is, and after you have found it, take a line of 1-in. pipe and run it down through the center of the well, at least 50 ft. below the water level, to make allowances for the water level falling when the well is in operation. Before putting down the air line, screw a plug into the end of the lower length of pipe. Then drill 1 ft. of that end of the pipe next to the plug full of 3/16-in. holes.

When at the desired depth, connect this 1-in. pipe to the air receiver. After the water is once set in motion, the air pressure can be considerably reduced and the same amount of water will flow from the well. Large sweep fittings should be used in this work.

His refrigerating problem, I think, is due to not draining his separator, together with a possible lack of sufficient ammonia in the system. H. W. ROSE.

Indicator Card Criticism

IN LOOKING through the Dec. 15 issue, I notice the indicator cards submitted by J. O. on page 1131.

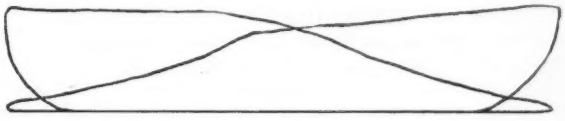
I believe the negative loops combined with late release and compression are in a large measure to blame for his trouble.

Even though 80 lb. back pressure is carried, there is (at 200 lb.) a pressure of 120 lb. additional forced into the cylinder, which is somewhat of a severe shock.

The steam line is extremely good and admission is taking place very quickly—in fact, maybe too quickly for the good of his engine.

The pressures on both sides of the piston are balanced at from approximately 63 to 78 per cent of the stroke.

After this period, the loop acts as a brake and creates even a greater difference in pressures at the beginning of the stroke. I would set the exhaust eccentric forward to show a good compression curve and if that did not remedy the loop on expansion curve, I would lower the boiler pressure until the loop disappears. The release is late and changing eccentric will remedy this also; 104 r.p.m. for a 42-in. stroke is not an excessive speed and 80 lb. back pressure is not prohibitive (triple expansion marine engines at times carry a very high first receiver pressure), but compression may be needed to cure the trouble, and no engine operates as smoothly with a negative expansion loop as without. On the same load, the loop must be even more pronounced on 200 lb. pressure, and no doubt this explains why bearings have burned out every four months, though I can't understand how such a thing could happen if the attendant was watching his machine closely.



PERHAPS A DESIRABLE FORM OF CARD

I would try getting a card similar to the sketch herewith and see how the machine operates.

TOM THUMB.

IF I WERE laboring under conditions such as J. O. describes on page 1131, Dec. 15 issue, I would reduce my exhaust valve lap a little, and if that proved of assistance, reduce it still more. The principal causes of crosshead and crankpin bearing troubles are as follows: The cylinder is having more steam admitted to one end than the other causing an unevenly balanced working condition in all stages. Compression may be too high. The pins are sometimes designed too small for the work the engine is doing. This can be corrected by installing larger pins. Sometimes an untrue pin may be the cause, or poorly fitted bearings, or the engine out of line. In this case, however, I believe that J. O.'s trouble is all caused by the high back pressure he is up against. I would like to hear from him again, as I may be of some future assistance to him. H. W. ROSE.

Sizing for Pipe Covering

KINDLY inform me how I can prepare a sizing to be applied to steam-pipe covering previous to painting.

F. P.

A. We quote a paragraph from Henley's Book of Formulas of a water-proof paint which would seem to suit your purpose.

"Mix glue water with zinc oxide (zinc white) and paint with this mixture. When this is dry (after about 2 hr.) it is followed up with a coating of glue water and zinc chloride in a highly diluted state. Zinc oxide enters into a chemical combination with zinc chloride, which acquires the hardness of glass and a mirror-like bright surface. Any desired colors can be prepared with the glue water (size) and are practically imperishable. This zinc coating is durable, dries quickly, and is 50 per cent cheaper than oil paint."

"THE MAN who would win success must look ahead to two battles: He must fight to reach the top and then struggle to stay there."

POWER PLANT ENGINEERING

Trade-mark, Reg. U. S. Pat. Office
(Established over 24 years.) Formerly PRACTICAL ENGINEER
PUBLISHED THE FIRST AND FIFTEENTH OF EACH MONTH
$1.50 A YEAR; 10 CENTS A COPY

BY THE TECHNICAL PUBLISHING CO.
537 South Dearborn Street, Chicago
New York Office, 150 Nassau St.

Notify us at once of any change of address, giving the old and the new address, so that your paper may always reach you promptly.

Copyright, 1920, by Technical Publishing Co.

Entered as second class matter May 1, 1908, at the Post Office at Chicago, Illinois, under the act of March 3, 1879.

Member, Associated Business Papers.
Member, Audit Bureau of Circulations.

Circulation of this issue 24,100

CONTENTS

Power House Foundations. By E. M. Lurie. Illustrated....167
Reversed Series Field on Generator. By Jas. T. Kane....173
Efficient Organization of Power Plant Help—II. By H. A. Wilcox 174
Bolshevism *Versus* Loyalty. By Jack Ball....176
E. G. Bailey. By Robert S. Coffin. Illustrated....177
Pump Troubles 178
Compressed Air Alarm. By J. H. Blakey. Illustrated....178
Coat the Boiler Setting. By H. M. Brayton....179
Efficiency in the Oil Room. By C. H. Davies. Illustrated...182
Advantage of Neighborhood Plant....183
A Study of Dynamo Electric Machinery—XI. By Ottomar H. Henschel. Illustrated 185
Temperature Indicators for Alternators. By S. L. Henderson. Illustrated 188
Floating Electric Power Station. Illustrated....192
Power Plant Troubles. By H. A. Jahnke. Illustrated....194
Electrical Machinery Demanded Abroad....195
The Hvid Engine. By E. B. Blakely. Illustrated....196
Pumping Hot Water....198
Nonreturn and Boiler Check and Stop Valves. By Charles B. Risley 199
New Heating System for Paper Mills. Illustrated....200
Letters Direct from the Plant: Faulty Feed Water Piping. Did the Engine Run Too Fast? Venting Low-Pressure Traps. Water Level Indicator. Ignorance in the Power House as Viewed from Another Angle. Blowoff Telltale. That National License Law. Christmas Trees. Overcoming Buckeye Engine Troubles. Illustrated....202
Questions and Answers: Will Gas Form in Storage Tank? Why the Knock? Oil Burning Equipment Steam Consumption. How Would You Stop the Leaks? Why Snow-Like Ice? Gear Calculations, Boiler Horsepower, etc. Conditions Essential to Complete Combustion. Reading U Tubes. Compressed Air and Refrigeration Problems. Indicator Card Criticism. What Caused the Knock? Sizing for Pipe Covering. Illustrated....208
Editorial: Railroad Legislation. Fixed Charges in Hydroelectric Plants 212
A Unique Shaft Coupling. Illustrated....214
The Automatic Substation—Its Economic Value....214
A Study of Load Curves. Illustrated....215
Origin of "Watch Your Step"....215
Book Reviews 216
Trade News 216

Railroad Legislation

No industry whatever is entirely independent of other industries, its raw materials come from somewhere and the finished product goes to some other establishment. It is true that some concerns do become more independent than others, but no single organization exists that does not rely upon outside industries to keep it functioning as a healthy concern should. The power plant is no different from other industries in this respect and those industries upon which we are most dependent for raw materials are the mines and the railroads.

After the experience of last November nobody will doubt our dependency upon the coal mines; without railroads, the country would be in even a worse condition in a shorter time. The policy of "live and let live" is just as essential among industries as among individuals. Our success depends more than we are prone to admit upon the efficiency, foresightedness and good judgment displayed in the conduct of the industries upon which we depend. Their ability to serve us in a more efficient way or purchase from us in greater quantities contributes to our success as well as theirs. So everybody in the country is vitally concerned in having the railroads conduct a successful industry which will be in harmony with all other business.

For 2 yr., the railroads have been operated by the Government under abnormal conditions, without profits and without the necessary improvements to keep them up to the demands of industry in general; but from all indications, they will be turned back to the owners on the first of March. The provisions of this transaction have not as yet been determined and it is impossible to do more than guess what the outcome will be. It is certain, however, that transportation facilities are crowded to the limit at the present time and it is estimated by the Railway Age that at least $6,000,000,000 will be needed within the next 3 yr. to bring the railroad tracks and equipment up to the demands being made upon them.

Any legislation which will be at all adequate must insure to the railroads the ability to raise sufficient capital to make the needed improvements and extensions. This means that the interest on investment must be sufficient to attract its share of capital in competition with other industrial enterprises.

Two bills are now being considered in Congress; these are the Esch bill in the House of Representatives and the Cummins bill in the Senate. The Esch bill, if enacted as presented and amended, would place practically the whole problem of Government control over the railroads in the hands of the Interstate Commerce Commission which would be increased in membership from nine to eleven. Besides questions of rates, this commission would still have administration of car service, construction and operation of switch and sidetrack connections, safety appliances, railroad accidents, hours of service, transportation of explosives, boiler inspection, block signal systems and appliances and many other duties of an administrative character. The bill authorizes the commission to employ subordinates not merely to assist but to decide and dispose of many important problems. This, according to railroad authorities, is one of the serious defects of the bill.

The Esch bill recognizes that the revenues from present rates will not suffice to keep many of the railroad companies out of bankruptcy and therefore provides a guarantee for a period of six months after federal control, but this guarantee is beset with complications not at all satisfactory to the railroad companies principally because the test period is not of sufficient length and will come during a season of the year which will work to their disadvantage.

Controversy also exists over the provisions for payment for the improvements made during the period of federal control. The bill requires that the amount due from the Government to any company, even for rental, shall be set off against amounts incurred for additions and betterments made during federal control; any balance due by the company may be funded into not exceeding ten equal annual payments, beginning five years after the termination of federal control, with interest at 6 per cent. The objection raised to this provision is that the time for payment is too short and will seriously injure the credit of railroad companies which will be left without any working capital and with debts on their hands for equipment bought by the Government under the stress of war at the abnormal prices then prevailing.

Further criticism is made of the Esch bill that it perpetuates every wage increase and every working rule or regulation made by the Railroad Administration during the war and the abnormal conditions resulting therefrom.

In the Cummins bill there is evident an honest attempt to solve the problem; the Interstate Commerce Commission is relieved of many of its duties which can be better performed by some other board and given additional duties of a much more important character; the Government is charged with responsibility of promoting the establishment of adequate railroad facilities through the agency of an appointed Transportation Board; means are provided for promoting the just settlement of all railroad labor disputes through tribunals created by the bill and strikes are prohibited under severe penalties; elaborate provisions are made for the consolidation of railroads into twenty to thirty competing systems.

In all, this bill seems to have sensed the needs of the industry with the exception of one feature which is meeting with severe yet just criticism when other provisions of the bill are considered. This feature relates to the dividends payable to stockholders, limiting them to 5½ per cent on the value of the property, permitting an additional ½ per cent for additions and betterments, and all net earnings above 6 per cent are to be divided, according to a definite plan, among the railroads, for improvements and the Government which would secure from ½ to ⅔ of all net earnings above 6 per cent of the value of the property. With the Interstate Commerce Commission in control of freight and passenger rates, this provision has no grounds for enactment and can only work to the detriment of the railroads and industry at large, which depends upon railways for transportation.

We all know that lack of proper legislation regarding the development of our water power resources has been a serious drawback to the country in the past; let us not put the railroads "on the rocks" by similar methods.

Charges in Hydroelectric Plants

The popular idea that hydroelectric power costs nothing, because Nature provides the necessary flow of the utilized stream is an interesting example of that tendency to jump to conclusions which is altogether too common, even in this enlightened country.

The operating sheets of a 20,000-kw. water power station which have recently come to hand throw considerable light upon this subject. The plant is located in the dam and last year turned out no less than 86,750,000 kw.-hr., or practically 50 per cent of the maximum possible with its equipment. To run this station there were required 24 production employes in the electrical department, besides various mechanical men, and the total operating and maintenance expense was $58,420, including wages, lubricants, repairs and station supplies. Pro-rated per kw.-hr., the total operating expense was only 0.068 ct.

A fair investment outlay for the plant, under the circumstances of its location and at the time it was built, would perhaps be $100 per kilowatt. On a $8,000,000 base if we allow 12 per cent for interest, depreciation, taxes and the small insurance required, the annual charges would be $240,000. Again reducing these to the unit output status, we find that no less than 0.277 ct. are required merely to carry the installation financially for every kilowatt-hour delivered to the busses. If the first cost of the plant and dam had been $150 per kilowatt, the total investment would have been $3,000,000 and the annual charges $360,000, or 0.415 ct. per kilowatt-hour. On the $100 per kilowatt investment basis, then, the total cost per kilowatt-hour in the year figures 0.345 ct., and on the basis of $150 per kilowatt, 0.482 ct.

The foregoing estimate (a combination of actual and estimated costs) may to some engineers appear to cover an unusually favorable condition on the operating side; but it should be realized that here we have a very large station running on an exceedingly good load-factor.

What do these points signify, in the large? They certainly emphasize the extraordinary importance of keeping down investment costs in water-power work and they also demonstrate that an operating company with a large station, high load-factor and sustained market does well to pay its employes good wages, for liberality in this direction can be pursued with very little adverse effect on the unit cost of production, if the yearly output is great. Perhaps at no previous time in the power producing industry were the services of expert designing and construction engineers of such great value in relation to their influence upon minimizing the final investment cost of a project as they are today. It is very doubtful if such a plant as the one in mind could be built now for the unit price first named above, and the importance of cutting down the "overhead" has assumed a tremendous weight. While the value of the power, both primary and secondary, and the market conditions as regards steam turbine plant competition, not to mention many other factors, must be considered in carrying forward a comprehensive development today, it is a safe general proposition that the lower the unit investment cost, the more chance such a project has of succeeding. Mere running costs are of nominal significance in a case like this, and the charges which the investment levies, while generally overlooked by the public, are all-important.

A Unique Shaft Coupling

IN THE accompanying illustrations is shown the construction and means of applying a new form of rigid coupling for joining well-loaded line shafts. Essentially it consists of a cast sleeve turned down to size and faced with drilled holes for the reception of hardened cup-ended steel pins which, after the sleeve has been placed on the shaft ends, may be driven home by means of a hammer. Doing so, as shown in Fig. 2, causes the cutting of keyways in the shaft of such depth as to insure inflexibility without impairment of strength. Due to the two opposite sets of pins employed, this action is

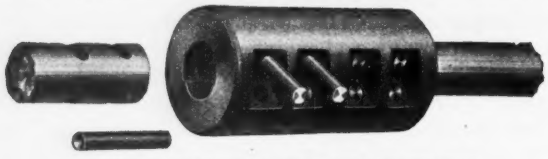


FIG. 1. APPLICATION OF SHAFT COUPLING

accompanied by the forcing of the two shafts against the edges of the recess in the opposite side of the base, a wedging effect forcing the metal of the shaft into the recess.

The Automatic Substation—Its Economic Value

THE TENDENCY in the development of modern electrical apparatus is to utilize more and more the automatic features which are proving to be important factors in extending its use.

No recent development has created more general interest or possesses more economic possibilities than that of the automatic substation, which, in simple language, consists of a synchronous converter, a bank of transformers and three or more switchboard panels on which are mounted electrically operated switches, relays and instruments. Without human aid, the converter starts up and reaches synchronism and assumes its share of the total load on the line. If the load increases to a point dangerous to the converter, it immediately shuts down and the line switches open. If a converter bearing should overheat, instantly a relay operates and the converter shuts down. If the load on the line drops to a point where the converter is not required, it automatically comes to rest. It will go through this cycle of starting and stopping just as often as line conditions make it necessary; it is possible to start up, close all switches, open all switches and stop the converter twice each minute.

Naturally, since such power is at instant call without an attendant at the station, certain limitations exist which react to counterbalance the good qualities of automatic switching, but they in no way destroy the great commercial advantages of such switching.

A competent engineer must inspect the apparatus weekly and the station must be cleaned up three or four times a month. One engineer can inspect many stations on a regular schedule, so this item will add but a trifling labor charge. The cleaning up can be done by ordinary labor. The original investment will, of course, be greater than for a manually operated station of equal capacity.

There may be increased hazard to the equipment, although results thus far obtained indicate that the equipment is better protected by automatic switching than by hand switching. The automatic switching is more complicated than hand switching, but on close acquaintance it becomes quite simple.

Since there are no operators to transfer high tension lines in case of trouble, these lines may in certain cases have to be arranged for automatic installations. It may be possible to handle this high tension switching by remote control.

The economic features which offset the foregoing disadvantages are so great that they leave a heavy balance in favor of the automatic switching. The fact that automatic substations require no attendants should itself effect an economy of $2500 per station, allowing two men per station for hand switching. Absence of attendants leads directly to a second marked advantage, the elimination of labor difficulties, an important factor under the present disturbed condition of labor generally. Since the automatic station shuts down when power is not required, the saving in energy will amount to a considerable item. No load losses are thus eliminated, which is particularly advantageous on interurban lines where the power requirements are intermittent. There is also a reduction in feeder loss, as the substation can be located exactly where needed, without reference to labor operating cost. By relocating or increasing the num-

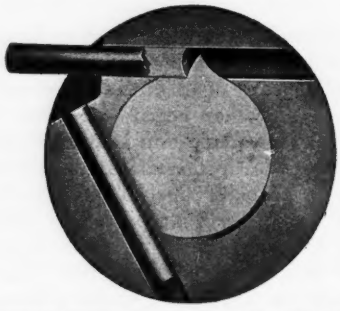


FIG. 2. SECTION THROUGH COUPLING AND SHAFT ILLUSTRATING CUTTING OF KEYWAYS

ber of substations, enough feeder copper can be saved in many instances to pay for a great proportion of the cost of automatic switching.

Experience thus far indicates that reliability of operation will be increased. Considering the ability of the best operators that can be secured and the introduction of the ever-varying human element, automatic switching should prove by far the more reliable method of operation.

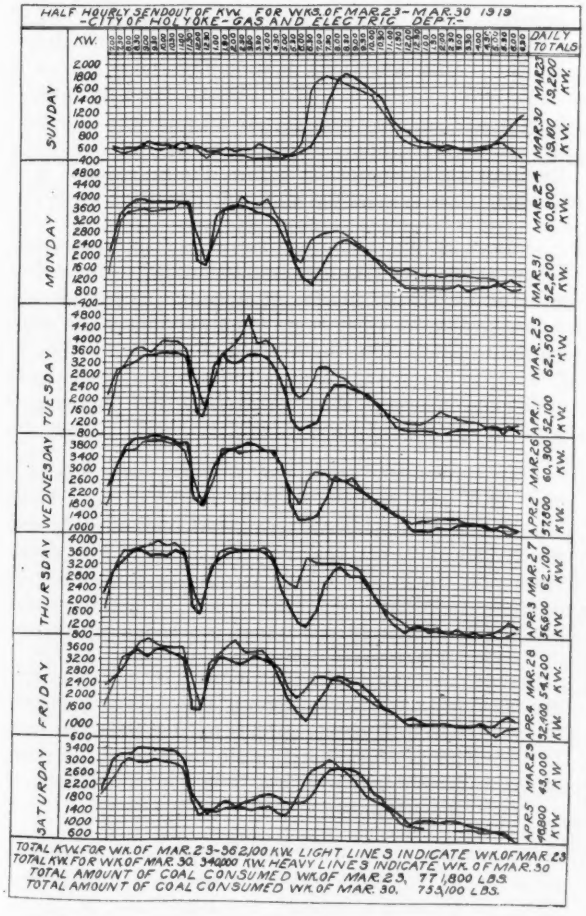
Maintenance has been very low in those cases which have been under operation. This charge will drop exactly in the proportion that inspection and cleaning of apparatus is kept up and with experience will doubtless drop to a very low value.

Summing up, there is no doubt that the automatic substation is here to stay, and its economic features demand consideration whenever the installation of a new substation is projected.

"IF YOU are filled with the gold fever stay at home and mine your mind."

A Study of Load Curves

ONLY through a study of the load curve of a plant is it possible to arrange the most economical program of operation. The load curve varies with several conditions, such as the day of the week, holidays, season of the year, weather, etc. One method of making this study is by means of curves drawn for the same day of the week one week apart, as shown in the accompanying chart. Among other things it is valuable


HALF HOURLY SENDOUT OF KW. FOR WKS. OF MAR. 23 - MAR. 30 1919
-CITY OF HOLYOKE-GAS AND ELECTRIC DEPT.-
KW.
DAILY TOTALS
SUNDAY
MONDAY
TUESDAY
WEDNESDAY
THURSDAY
FRIDAY
SATURDAY
MAR. 23 19,200 KW.
MAR. 30 13,800 KW.
MAR. 24 60,800 KW.
MAR. 31 32,200 KW.
MAR. 25 62,500 KW.
APR. 1 32,100 KW.
MAR. 26 60,300 KW.
APR. 2 17,000 KW.
MAR. 27 62,100 KW.
APR. 3 16,600 KW.
MAR. 28 54,200 KW.
APR. 4 32,400 KW.
MAR. 29 43,000 KW.
APR. 5 19,800 KW.
TOTAL KW. FOR WK. OF MAR. 23 - 362,100 KW. LIGHT LINES INDICATE WK. OF MAR. 23
TOTAL KW. FOR WK. OF MAR. 30. 340,000 KW. HEAVY LINES INDICATE WK. OF MAR. 30
TOTAL AMOUNT OF COAL CONSUMED WK. OF MAR. 23. 77 1,800 LBS.
TOTAL AMOUNT OF COAL CONSUMED WK. OF MAR. 30. 735,100 LBS.

INTERESTING LOAD CURVES DRAWN ONE WEEK APART

to note how the peak of the lighting load shifted to about one hour later for the second week and in most cases is considerably less, and the hollow between power and lighting loads, which occurs between 5 and 7:30 o'clock, is considerably more pronounced during the second week.

U. S. CIVIL SERVICE COMMISSION announces an examination for mechanical draftsman in the office of the Chief of Ordnance, War Department, Washington, D. C., and in the Ordnance Department at Large, at the entrance salaries indicated: Grade 1, $800 to $1400; grade 2, $1400 to $1800; grade 3, $1800 to $2500 a year. Men are preferred for appointment to positions in Grades 2 and 3. Applicants must have reached their eighteenth birthday on the date of application, submit their photographs, and samples of work. Ask for Form 1312.

Origin of "Watch Your Step"

FROM AN analysis of nearly 10,000 accidents recently reported by manufacturers, chiefly electrical, in the United States, the highest percentage of those that occurred outside the companies' premises were attributed to slipping, tripping and falling, hence the origin of "Watch Your Step." This means that the greatest danger lying in wait for a man in his hours of leisure is the pavement beneath his feet. The highest percentage of falls came from those occurring on the level, while others came in the following order of seriousness; from elevations, from ladders, over obstructions, on stairs, from poles, into excavations, from temporary supports and from scaffolds.

On the companies' premises, "handling material" comes first. Accidents from electric current—from shock, burns, eye-flash—rank fourth in a list of eighteen classes of accidents. Only 0.7 per cent of all the accidents reported were due to exhaustion from heat, which seems strange; one imagines that more suffer from heat prostration than is actually recorded.

From a general consideration, injuries to fingers were highest, eyes next, and ears last in a classification of 35 anatomical locations. From the standpoint of occupation, linemen ranked first and carpenters lowest.

Perhaps the most interesting classification is that which considered the length of service. Of all the accidents reported, 25.9 per cent, or the highest single percentage, had all been in the employ of the companies less than 6 mo. Those veterans of over 20 yr. service contributed only 1.1 per cent to the casualty list.

To determine the seriousness of the various causes of accidents, by consideration of the number only, resulting from each cause is misleading. While only 8.3 per cent were injured by electric current, these accidents were responsible for over 70 per cent of the total lost time and 70 per cent of the serious and fatal accidents. The fact is, however, and it is encouraging, that 75 per cent of this class of accidents are preventable, when the proper safety devices, such as enclosed switches, rubber gloves, etc., are installed, while falling will continue as long as man fails to "watch his step."

THE COLLEGE OF ENGINEERING of the University of Illinois reports the following appointments which have been made since the beginning of the academic year in September:

Matthew Rutherford Riddell as Assistant Professor of Aeronautic Engineering and Assistant to the Director of the Engineering Experiment Station; Jesse Benjamin Kommers as special Research Associate Professor of Engineering Materials in the Engineering Experiment Station on the Investigation of the Fatigue of Metals; Floyd Hamilton Fish as Special Research Assistant in Engineering Materials in the Engineering Experiment Station on the Investigation of the Fatigue of Metals; Elmer Newman Bunting as Research Associate in Ceramic Engineering in the Engineering Experiment Station; Roswell Miller Rennie as Superintendent of the Machine Shop in the Department of Mechanical Engineering; and Oscar William Schricker as Assistant Superintendent of the Machine Shop in the Department of Mechanical Engineering.

Book Reviews

How to Make and Use Graphic Charts, by Allan C. Haskell, New York, 1920; price, $5.

The use of graphic methods for presenting facts has grown to a remarkable degree; and especially during the war, when time was the main factor, did it gain a big impetus.

There are very few books on the subject and of these nearly all are too theoretical to be of real benefit to the average business man. In fact, there is but one that we know of, which is written in non-technical language. While this is an admirable book, it does not show the application of charts to the solution of specific problems, but rather gives a general description of rectilinear charts without telling just what can be done with them, and practically ignores many of the best and most modern kinds of charts.

This new book, however, by Allan C. Haskell, with an introductory chapter by Richard T. Dana, is not ultra-technical, but gives enough theory to make the underlying principles clear. It tells how to make all kinds of charts—rectilinear, logarithmic, semi-logarithmic, isometric, trilinear, polar, alinement, etc., and then shows by well chosen descriptions and illustrations just what charts are best fitted for certain purposes.

The charts have been grouped under various heads, such as: organization and management, costs and cost analysis, scheduling and progress, results of tests and experiments, trends, computation, etc., so that the business man, the cost analyst, the statistician, the engineer, the instructor, the student, may find with least expenditure of time and effort the answers to his own personal problems.

A preliminary report of progress under the present co-operative agreement between the National Warm-Air Heating and Ventilating Association and the University of Illinois for an investigation of warm-air furnaces and furnace heating systems, has been issued by the Engineering Experiment Station of the University of Illinois as Bulletin 112, by Professor A. C. Willard.

The principal objects of the investigation are:

(1) To determine the efficiency and capacity of commercial warm-air furnaces under conditions similar to those existing in actual installations with leaders, stacks, and registers, to form a complete system.

(2) To determine satisfactory and simple methods for rating furnaces so that the proper size and type of furnace can be definitely selected for the service required.

(3) To determine methods of increasing efficiency and capacity of furnace heating equipment and the advantages or desirability of certain types of design.

(4) To determine the heat losses in furnace heating systems and the value of insulating materials as affecting the economy of the furnace or the leaders and stacks, and finally of the system as a whole.

(5) To determine the proper sizes and proportions of leaders, stacks, and registers supplying air to first, second, and third floors.

(6) To determine the friction losses in the cold air or recirculating ducts and registers and their proper size, proportions, and arrangement or location.

(7) Eventually, to make a study and comparison of outside and inside air circulation as affecting the economy and operation of furnace systems.

Copies of Bulletin No. 112 may be had without charge by addressing the Engineering Experiment Station, Urbana, Ill.

Trade News

The Combustion Engineering Corporation has enlarged its facilities for handling business in the Philadelphia territory. The office of the company in this territory is located in the Lincoln Building and W. C. Stripe, formerly of its Pittsburgh office and formerly of the Westinghouse Co., becomes manager of the Philadelphia district. Associated with him in that territory on the active selling force are C. L. Bachman, recently returned from active military service abroad and who was formerly manager of the Chicago office of the Combustion Engineering Corporation before the war, and E. F. Kuehnle, formerly of the main office in New York.

Frank H. Nickle, manufacturer of agitator driving yokes, a standard power transmission device for driving agitator or stirrer shafts in open or closed chemical tanks, kettles, or other containers, announces the organization of the Nickle Engineering Works, with office and factory in Saginaw, Mich. The company will install additional machine shop equipment and increase the scope of operations.

The Hills-McCanna Co. recently moved into its new office and factory at 2025 Elston Ave., Chicago. The change was made on account of increasing business which had outgrown the former quarters. The present factory is entirely modern in all its equipment and occupies four times as much space as was previously available, the foundry now having a capacity of 4 tons.

In order to meet and cope more fully with the growing demand for refrigerating and ice making machinery, the Carbondale Machine Co. has opened an office in the Ellicott Square Building, Buffalo, New York, in charge of H. J. Botchford, who has been connected with this company for a number of years.

Announcement of 1919-20 courses of Shepard Technical Night School was lately received from Shepard Electric Crane & Hoist Co., Montour Falls, N. Y.

Power in Industry and Commerce is the title of a pamphlet discussing the aims and methods of Fuel Engineering Co., of New York, in dealing with power plant problems affecting its clients.

G-R Instantaneous Heater, for use where large quantities of hot water are required to be heated by live or exhaust steam, as a hot water converter, and as a boiler feed water heater, is the subject of Bulletin No. 231, just issued by The Griscom-Russell Co., 90 West St., New York.

Catalog No. 12 of The Brown Instrument Co., Philadelphia, on the subject of Brown pyrometers, contains 88 pages elaborately illustrated with halftones and diagrams. It also gives much information regarding resistance thermometers, recording thermometers, pressure and draft gages, tachometers, time and operation recorders and other instruments manufactured by the company.